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HYGIENE AND PUBLIC HEALTH

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A TREATISE ON

HYGIENE AND PUBLIC HEALTH

With Special Reference to the Tropics

BY

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PREFACE TO THE FIFTH EDITION

ALTHOUGH the last edition of this work was published only three years ago, the changes in the present edition are extensive. Practically every chapter has been carefully revised and new material added to each.

In the chapter on water, filtration has been more fully discussed, paying special attention to the description of rapid or mechanical filters. The subject of chlorination of water, which, since the experience of the last war, has assumed an important position has been specially dealt with.

The disposal of refuse, incineration of night-soil and the different types of latrines used with so much success during the war have been described in detail. The chapter on disposal of sewage has been entirely recast, and a special article has been written on the activated sludge process.

The chapter on insects has been practically re-written, and new articles on Conorhinus and Lice have been added.

A fresh chapter on Fairs and Melas has been introduced and a new article on Anthrax has been added in the list of preventable diseases.

Many old illustrations have been replaced by new and better ones, and about thirtyseven new diagrams have been added. Some of these illustrations have been taken from The Medical History of the War by kind permission of the Controller of H. M. Stationery Office.

In the preparation of this edition I derived valuable help from "The Medical History of the War," specially the volumes dealing with the Hygiene of the War; "Preventive Medicine and Hygiene" by Rosenau; "Practical Sanitation" by George Reid; "Manual of Hygiene" by Glaister, and the "Public Health Manual" issued by the Government of Bengal.

I wish to take this opportunity of expressing gratitude to my friend Dr. Jahar Lal Das, D. P. H., who was associated with me as joint author, and whose valuaable collaboration contributed so much to the success of this book. To Col. A. B. Fry, I.M.S., Professor of Hygiene, Calcutta School of Tropical Medicine and Major A. D. Stewart, I.M.S., Professor of Hygiene, Calcutta Medical College, I am indebted for valuable help and suggestions ; and I am thankful to Dr. Santosh Kumar Mukherji, M.B., for going through the proofs and revising the index, and thereby considerably minimising my labour.

Notwithstanding the utmost effort at condensation and elimination, it has been found necessary to increase the size of the book by seventynine pages. I trust, however, that the book will continue to maintain its position as an up-to-date and reliable text-book for students and other public health workers in the tropics.

CALCUTTA,
May, 1924

B. N. GHOSH

PREFACE TO THE FIRST EDITION

So much attention is being paid by the Government to the sanitation of India that no apology is needed for the appearance of this book. A book which is neither too large nor too small, written in the form of a text-book and having special reference to the tropical climates, has been a distinct want. But it must be said at the outset that we do not presume to replace any of the standard works on the subject—far from us be any such intention. On the contrary, we have drawn largely from most of those works, and have received valuable assistance from Notter and Firth's *Theory and Practice of Hygiene,* Parkes and Kenwood's *Hygiene and Public Health,* Newsholme's *Hygiene,* and McNally and Cornwall's *Sanitary Handbook for India.* Particular attention has been paid to the description of food, disposal of refuse and septic tanks. In the preparation of these portions we are especially indebted to the works of Hutchison, McCay, Burney Yeo, Sutherland, and Clemesha. A few pages have been devoted to the description of insects as carriers of diseases, and the chapter on infectious diseases has been written with special care, giving the latest information with regard to preventive measures. Besides the authors already alluded to, we are grateful to many others, especially to Sir Patrick Manson, Lefroy, Hehir, Sir Ronald Ross, and to Sir Pardey Lukis and Major Blackham, whose latest work on *Tropical Hygiene* has been of the greatest use to us.

It has been our endeavour to make the treatise concise, thoroughly reliable, and up-to-date.

B. N. GHOSH
J. L. DAS

CALCUTTA, *October,* 1912

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HYGIENE AND PUBLIC HEALTH

CHAPTER I

WATER

WATER, though not strictly speaking a food, is absolutely necessary for the maintenance of life, both animal and vegetable. It is mainly used as a solvent and diluent in the human economy, but for these purposes only a small quantity would suffice. With the progress of civilisation, however, the demand for water has considerably increased and it is now required for :—

1. Domestic use for the following purposes :—
   (a) As food for building the tissues of the body, maintaining the fluidity of the blood, and helping in the excretion of waste matters.
   (b) Cooking and washing.
   (c) Personal cleanliness.
2. Municipal and trade purposes.
3. Hospitals.
4. Washing stables and carriages, and for horses.

A liberal supply of pure water is of primary sanitary importance.

Quantity of Water required.—The amount of water required daily for domestic use varies greatly, and depends mainly on the habits of the people and the particular sanitary arrangements of the place. From a sanitary stand point one should encourage a free use of water and at the same time discourage unnecessary waste. For modern requirements of health and cleanliness a sufficient amount of water is of utmost value. The quantity of

water required has been variously estimated by different observers. Parkes and Kenwood give the following as the daily allowance for all purposes :—

		Gallons per head.
Household	Fluids as drink	0.33
	Cooking	0.75
	Ablution	5.00
	Utensil and house washing	3.00
	Laundry washing	3.00
	Water-closets	5.00
Trade and manufacturing		5.00
Municipal	Watering streets, baths, fountains, flushing sewers, and extinguishing fires	5.00
	TOTAL	27.08

A most important factor in the supply of pure water in a large city is the prevention of waste. While it is possible that certain amount of wastage is unavoidable the greater part of it is preventable. The principal causes of this waste are (*a*) faulty mains and service pipes ; (*b*) leakage from stop cocks in the house ; (*c*) storing water in reservoirs, etc., for daily use and throwing away the same every day ; and (*d*) allowing the water to run at night or when not required.

In hospitals 40 to 50 gallons per head must be supplied daily. In Calcutta the daily allowance per head is as much as 32·6 to 39·7 gallons.

A horse needs about 15 gallons and a cow 12 gallons per day. This amount, however, varies with the season and the size of the animal.

SOURCES OF WATER

All water is primarily derived from the *ocean*, and in tropical regions the evaporation of water into the air is very great, and it has been estimated that about 700 gallons are evaporated every minute from each square mile of ocean surface. Winds blowing over a large expanse of water become laden with moisture, and as soon as

the cooling effect is produced by a lower temperature, it returns to the earth as *rain, snow, dew, mist* or *hail.* It follows, therefore, that the *condensed water* from the air is the principal source of all our natural water supply. But the following are the common direct sources :—

I. **Rain Water.**—Rain as it falls is the purest water which occurs in nature. On reaching the surface of the ground part of it is evaporated, part flows to form rivers, etc., and helps to feed tanks and lakes, while the rest percolates into the soil and in so doing absorbs carbonic acid from the ground air. In passing through the air it takes up certain gases chiefly nitrogen, oxygen, a little carbonic acid, traces of saline matter, common salt, sulphates, particles of suspended matter, soot, dust, microbes, etc. The composition of rain water therefore varies with the purity of the atmosphere through which it has passed. When collected from the surface of the ground the area should be especially constructed for the purpose and rendered impervious by cementing. The number of bacteria found in rain water in winter is less than in summer, and the water sometimes becomes coloured from the presence of *protococcus pluvialis* and spores of fungi.

Rain water in manufacturing towns is unfit for human consumption as it becomes mixed with sulphurous and sulphuric acid, soot, etc. When collected from the roofs of houses the first portion is usually dirty as it generally contains animal matter from the droppings of birds, street dust, eggs of insects, soot, etc., and should therefore be thrown away. By fixing "Roberts' Rainwater Separator" on the rain-water pipe the latter portion of rain water can be collected as it allows the first portion to run to waste.

Rain water is naturally free from pathogenic organisms, especially cholera and enteric germs. When a good supply of water cannot be had rain water may be used for drinking purposes if collected and stored with proper precautions. It is very soft owing to the absence of salts of lime and magnesia, and is therefore suitable for cooking, washing, and bathing purposes. It is very palatable,

being much aerated, but it has a corrosive action on lead. No reliance can be placed on rain water as a continuous source of supply owing to the method of collection and storing in a manner which exposes it to all sorts of infection; Stegomyia calopus breeds by preference in artificial cisterns holding rain water.

The amount of rain which falls is measured by a *rain gauge* (*q.v.*), and is expressed in inches of depth. A rainfall of 1 in. in depth corresponds to about $4\frac{3}{4}$ gallons on a square yard, or 22,617 gallons (101 tons) on each acre.

The following formula is generally used :—

$$\frac{\text{Area in sq. ft.} \times 144 \times R}{1728} = \text{water in cubic feet.}$$

R = rainfall in inches.

In one cubic foot of water there are about $6\frac{1}{4}$ gallons (6.23 gallons) of water.

In estimating the annual yield of water from rainfall and the yield at any particular time, we must know the maximum annual rainfall, the minimum, the average, and the period of the year when it falls, and the length of the rainless season.

II. Snow Water and Ice.—These are fairly pure, but if ice be derived from polluted water it is not free from danger.

III. Upland Surface Water.—This is water collected and stored in hilly districts at the head of rivulets or streamlets. The water may be collected in some natural lakes as in Loch Katrine, for the supply of Glasgow, or in some artificially constructed lakes made by building an earth or masonry dam across the outlet of the valley, as in the cities of Bombay and Liverpool. Such a water nearly approaches rain water in purity. There is an absence of ammonia, nitrites and nitrates, and it is almost always soft and contains little dissolved saline. Frequently it contains dissolved organic impurities derived from sewage and decayed vegetable matter. If the hills are covered with peat the water may be brownish from dissolved peaty matter. Unless in excess this water is practically harmless, but if impregnated with too much

peat it is said to give rise to diarrhœa. It can however be removed by running the water through a bed of sand. It has been shown recently that there are acid-producing bacteria in the peat, giving the water an acid reaction, and cases of " plumbism " have occurred from the use of such water distributed through lead pipes. When such water is used for drinking purposes it should be protected from pollution.

IV. **Springs** derive their water-supply from the rain water which, falling upon a pervious surface as sand, gravel and chalk, and percolating through the soil, is accumulated there. This water is then known as the *subsoil* or *ground water*. Beneath the pervious rock there is always at a greater or lesser depth a stratum of impervious character which holds up the water. The surface of this stratum is however sloping, and the water runs along this until the impervious stratum reaches the surface of the soil, where it issues as a spring. Springs therefore may be regarded as natural wells outcropping where the geological formation is favourable.

Springs are of the following kinds :—

(*a*) *Land Springs* originate from percolation of water through beds of sand or gravel overlying an impervious stratum, and in fact are outlets of limited collections of subsoil water. They are often intermittent, ceasing to flow in summer (April to September) and starting again in autumn (October) after percolation has commenced.

(*b*) *Main Springs* are deep-seated springs issuing from regular geological formations, *e.g.*, chalk, oolite, greensand, etc. They usually give a continuous supply with certain variations during the different periods of the year.

(*c*) *Intermittent Springs* are usually found in valleys bounded by rivers and high hills. The flow depends on the amount of rain and subsoil water.

(*d*) *Hot or Thermal Springs.*—Where volcanic eruptions have ceased evidence of high internal temperature is often to be found in springs which continue to maintain their heat even for centuries. Thermal springs are not confined to volcanic districts alone, they may arise even

in places hundreds of miles away from any active volcanic vent. As instances of this kind may be mentioned the *Sitakoond Spring* in India, and hot springs of Bath and Buxton in England.

Springs afford good sources of water-supply for small communities such as villages. Spring water as a rule is of a high degree of purity and since no mechanical means are necessary to draw the water it is less liable to contamination. The greater the degree of percolation the water undergoes, the more perfect is the filtration and more clear and bright it becomes. It is generally cool and palatable. Spring water is highly charged with carbonic acid gas obtained from the ground air; aided by this and increased pressure it dissolves out lime and various mineral salts through which it passes, consequently it is hard and less suited for washing and cooking purposes.

The temperature of springs affords a convenient but not always a quite reliable guide of the relative depth from which they have arisen. Some are just above the temperature of ice, others issue at the temperature of boiling water, and between these two extremes every degree may be registered, since the temperature of the earth rises approximately about 1° F. for a depth of every 50 ft. or 60 ft.

Springs are also liable to contamination, therefore if water is used for drinking purposes it requires to be protected. Thus a leaky cesspool above a spring may contaminate the water directly. Stables, privies, etc., should be located at a considerable distance. The spring should be protected by a concrete wall which should extend well into the ground and thus protect pollution from surface washings. The surface water which would otherwise pollute spring water should be carried away by a specially constructed drain.

Yield of a Spring.—This is estimated by taking a vessel of known capacity and observing how long it takes the spring to fill it up. The output of the spring in one hour can thus be determined, and as the allowance per head is known the total quantity required is calculated.

V. **Wells.**—A well is an artificial pit or hole dug below the water-level into which the subsoil water percolates. Wells form an important source of water-supply in Indian villages. Formerly they were in use in certain towns also, but have now been abolished in favour of public water-supply which has been introduced in most towns. There are three kinds of wells :—

(*a*) Shallow or surface wells.

(*b*) Deep wells.

(*c*) Artesian wells.

(*a*) *Shallow Wells.*—Wells sunk into a superficial porous bed of sand or gravel which overlies an impervious layer of clay or rock are known as *Shallow Wells.* These wells draw mainly from the subsoil or ground water which percolates into them from the surrounding superficial soil, and therefore such water should be looked upon with suspicion, as it generally becomes contaminated by impurities from the surface of the soil. When contaminated with animal pollutions such a supply becomes even more dangerous. These wells are very often situated close to drains, privies, and other sources of pollution, with the result that the offensive matters drain into them and make the water more foul. If the soil be of a porous nature these impurities percolate into the shallow wells whose water they highly contaminate. Trees grow at the edge, plants sprout from the lining, and dead leaves fall and rot in the water. Birds build nests in the crevices, and fish and turtles are frequently put in the well to keep it clean. Every user of the well brings his own vessel and rope for drawing water and the rope in the intervals of duty may tether a cow or lie in some dirty corner. In addition to these sources of impurities the surface well may also be a source of danger from more distant contamination. The supply of these wells is the underground stream moving steadily in the direction of its natural outlet, and heavy rains by raising the level of ground water may wash impurities from leaking cess-pools, etc., into wells lying between and below the source of contamination and the outlet (Fig. 1).

The danger of pollution in the case of surface wells may be reduced if the walls are made of impervious mate-

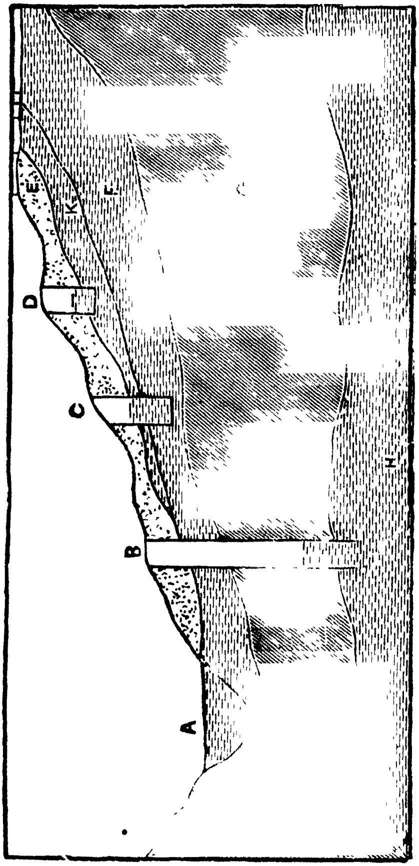


FIG. 1.—DIAGRAMMATIC REPRESENTATION OF STRATA.

A, Surface water; B, Deep Well; C, Shallow Well; D, Cesspool; E, Porous soil; F, Subsoil water; G, impermeable strata; H, subterranean water in deep strata; K, the rise in the level of subsoil water and pollution of shallow well from Cesspool D.

rial, as solid brickwork set in cement, or glazed earthenware tubes, or iron cylinders. The area round the mouth of the well should be made water-tight with reinforced concrete with a cement surface to form an impervious platform, and properly drained beyond what is known as

the *cone of filtration* (*q.v.* page 10), and brought up to about 2 ft. above the level of the ground in the form of a parapet wall to prevent surface washings from entering it. The upper part of this coping should be sloped to prevent vessels, etc., from being placed on it. The platform should be sloping all round and provided with a channelled drain leading to a *pucca* drain which carries the water at a distance. The well should be protected by a cover provided with holes for ventilation. They should always be at a distance from any habitation, and at least 50 ft. away from any source of pollution.

Shallow wells should whenever possible be avoided, but if at all used they should as far as possible be improved or reconstructed. As an additional precaution a layer of gravel covered by a deep layer of sand should be deposited on the bottom.

Norton's Abyssinian Tube Wells are used when a temporary supply is wanted. These consist of tubes screwed one over the other and are commonly 20 ft. to 25 ft. deep. To construct one a hole is made in the soil about 4 ft. to 5 ft. deep, and the first part of the tube which has a perforated steel point at its lower end hammered in. Successive lengths of tubes are driven into the soil, one length being screwed on to the other. When the subsoil water is reached a pump is fixed and the first portion is drawn out till clear water is available.

These wells are more suitable for gravel, chalk, and other water-bearing strata, but the sandy bed of an old river is an ideal place, as hard rocks prevent the tube from being driven down.

Although these tube wells are somewhat superior to surface wells, the same objections may be urged against them as they do not go down deep.

(*b*) *Deep Wells.*—Deep wells are those which pass through a superficial porous bed and an underlying impervious stratum to reach the water-bearing strata. The casing of these wells are also to be made of some impermeable material as described under shallow wells and

should extend as deeply into the well as possible, or down to the level of the impervious stratum, so that the water percolating from the surface will have to pass through the soil before entering the well. During this passage the organic impurities will to a certain extent be removed.

Deep wells are generally good sources of supply on account of the efficient filtration the water undergoes. They are singularly free from organic impurities. Inorganic impurities are sometimes common which render them unfit for domestic purposes. They may also contain an excess of lime and common salts. But nevertheless they are exposed to contamination from sources similar to those of surface wells, especially when they are sunk in a pervious stratum like chalk or sandstone, and they should be constructed and protected as shallow wells.

(c) *Artesian Wells.*—These are formed when a boring taps the water in a pervious layer lying between two impervious ones—the pervious layer having its outcrop on the surface at a much higher level than the point where the hole is made. The water when so tapped will avail itself of this artificial channel and will rise or even gush out above the ground. These are so called after the old province of Artois, where they have been in use for a long time.

Area drained by a Well.—This is usually about four times the depth of the well and may be even more. Roughly, a well drains an area around it which may be regarded as an inverted cone the apex being represented by the bottom of the well. This drained area is popularly known as the "cone of filtration." If a shallow well be hard pumped the distance drained may exceed the above area. It follows, therefore, that if there be any source of pollution within this area contamination will inevitably occur. This draining will depend on the nature of the soil and the amount of depression of the water-level due to pumping. Care should therefore be taken to select a site where any such contamination is impossible, and the distance of the well from such polluting source should be 100 to 160 times the difference in the level of the water

in the well that might possibly be produced by hard pumping.

Sources of Pollution.—The following are the principal sources :—

1. *Cesspools, privies, pervious drains and other collections of filth* near about are mostly responsible for the pollution of ordinary wells, as connection may be established after a sudden rise in the subsoil water or by percolation (Fig. 1.)

2. *Rivers.*—By direct connection dirty water may gain access to a well ; this is rare.

3. *Graveyards*, especially when subsoil water comes up to the level of the buried bodies.

4. *Cracks* or *fissures* in the soil which may result from an earthquake.

5. *Trees* by sending roots down may help in admitting surface water into wells.

6. *Rat holes* near about the well may help polluting matter to pass into the well.

To ascertain whether a well water is polluted and the source through which the polluting material reaches the well, solutions of common salt, lithia salts, alkaline solution of fluorescin, paraffin oil or an emulsion of *bacillus prodigiosus* are employed. These when introduced into drains, cesspools, or other supposed sources of mischief may be found in the well water, if the suspicion be correct, by virtue of their colour, taste, or chemical properties even though largely diluted.

It may be observed that a highly contaminated water becomes clear and deprived of its suspended organic matter during its passage to a shallow well. The appearance of the water under such conditions becomes deceptive, but nevertheless it retains its dangerous properties. The sparkling appearance and palatability are due to dissolved CO_2 gas. Polluted water of shallow wells is hard, and therefore unfit for domestic uses.

Examination of Wells.—In examining a well the following points deserve attention :—

(*a*) Any source of pollution within 200 ft. to 300 ft. of the well.

(*b*) Whether any adequate or proper coating lines the sides of the well, or whether there are cracks or fissures on the sides.

(*c*) Depth of the well.

(*d*) Depth of the water in the well.

(*e*) Nature of the soil in which the well is sunk.

(*f*) Purposes for which the well is used.

(*g*) Average quantity of water daily drawn.

(*h*) Habits of the people using it.

(*i*) The way in which waste water is disposed of.

(*j*) Whether there has been any recent rain, if so, its nature.

The **yield** of water from a well can be determined by pumping water out to a certain level and noting the length of time required in its regaining the original level.

Ideal Well.—An ideal well should satisfy the following conditions :—

1. It should always be sunk in a good soil.

2. The casing of the well should be made of solid brick work and lined with cement about 1 in. thick and the water should come only from the bottom. The joints should be made water-tight if the well is lined with pipes. The outer surface between the casing and the earth should be thoroughly rammed in with puddled clay to prevent the admission of surface water into the well (*see* Fig. 2).

3. The surrounding area (platform) at the top should be so sloped as to allow water to drain off readily.

4. The well should be provided with either a pump, which should be fixed on the platform, or a special bucket and chain or rope, and no other vessel should be used for drawing up water.

5. The area surrounding the well to about 6 ft. all round the opening should be made *pucca* so as to convert it into a masonry platform with a proper slope. No washing of clothes should be permitted there.

6. All rat holes, hollows, and foul tanks near about should be filled up and adjoining trees cut down.

7. The top of every well should have a suitable covering with openings for ventilation. To facilitate cleansing

climbing hooks should be fixed to the wall at the time of steining it.

8. It should be at a considerable distance (250 ft.) from any sewage farm, open drain, or trenching ground, or any source of pollution, and at a reasonable distance (80 to 100 ft.) from any human habitation or *bustee*.

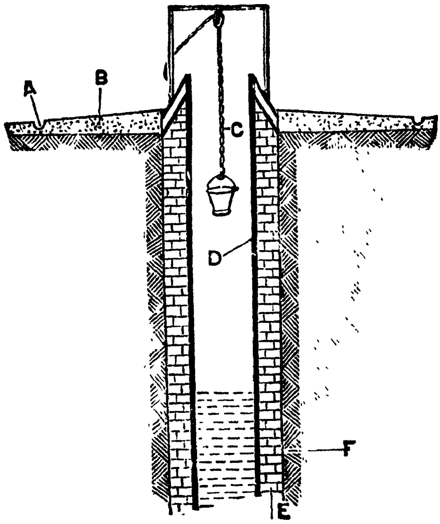


FIG. 2.—AN IDEAL WELL.

A, Chanelled drain; B, Platform; C, Chain, pulley, and bucket; D, Cement lining; E, Brickwork; F, Puddled clay.

Cleansing of Wells.—All wells must be dewatered and thoroughly cleansed at least once a year. Cleansing is best done at the close of the hot season when the water remains at its lowest level. The water of a well which has neither been used nor cleansed for some time contains a large amount of organic matter and should therefore be cleansed before using. Cleansing is done by scraping the sides and removing all mud and rubbish which block the pores

at the bottom of the well. The sides and the bottom should then be covered with quicklime.

Deep Tube Wells.—Recently deep tube wells have been introduced for the supply of drinking water. Their depth usually varies from 100 to 500 feet depending upon the strata, and ordinarily yields from 1000 to 5000 gallons of water per hour, but this depends upon the diameter of the tube.

The water obtained from these wells specially in Bengal is as a rule pure. Thus the water from some of the wells do not show fæcal bacilli in 60 c.c., while others show evidences of fæcal contamination. This contamination generally takes place during construction. Faults in the substrata may cause leakage in the subsoil water and may cause pollution.

These wells require to be carefully managed and one must know the limitation of their working speed as they silt up if the rate of pumping exceeds the critical velocity. When water is drawn the level of the water in the well is lowered and as a consequence thereof the water will tend to flow into it from the surrounding ground. The area within which the level is appreciably lowered is called the " circle or cone of influence."

1. The closed or driven well.—In this form the well tube is closed and pointed at one end, and perforated at some distance therefrom. This tube is driven into the ground until it penetrates the water-bearing stratum. This method of boring is done with shallow tube wells, but where the depth exceeds 75 to 100 ft. the method of sinking is different.

2. In the other form the boring is done by an outer tube consisting of a steel cutting wedge screwed on to the end. This is subsequently replaced by an inner tube or the well proper. In this process a strong stream of water is run which escapes in one or more jets near the end of the pipe, and the loosened earth is carried to the surface by this water. It has therefore a great sanitary significance, for if a bad water is used it will infect the new tube well water which may take several months to clear.

VI. **Tanks.**—Tanks are good sources of water-supply if free from pollution, and are perhaps the only sources of water in most villages ; but they are commonly made foul by being used for washing and bathing purposes, by the passage of excrement direct into the water, and by rotten leaves and other impurities. There should be very little chlorine in tank water. The presence of chlorine. nitrites, and ammonia makes the water suspicious.

Common sources of pollution of tanks in Indian villages are :—

1. Insanitary habits of the people.
2. Cattle washing.
3. Steeping of jute and bamboo.
4. Contamination by decayed leaves, weeds, and vegetable matter.
5. Surface drainage from foul areas around the tank.

When tanks are used for drinking purposes the following points should be attended to :—

(*a*) They should be excavated in a good soil having good surroundings : " made soil " and loose sandy soil having filthy ponds and cesspits in the vicinity should be avoided.

(*b*) They should be large, of a regular shape and deep. The water surface should be about three *bighas* (one acre), with a catch-water area surrounding it of equal extent.

(*c*) Banks should be properly sloped and covered with grass, and the edge or shore should be higher than the level of the surrounding land, so that no water can enter the tank except the direct rainfall over the conserved area supplemented by subsoil water from the bottom.

(*d*) They should be *fenced* in or enclosed by railings. Trees should be planted at a fair distance to keep away dust.

(*e*) No bathing or washing of clothes or utensils should be permitted, nor should there be any steps or *ghats*. An ideal arrangement is to employ a special man with a separate bucket, or to fix a hand-pump.

(*f*) Arrangements for drawing water from a platform or jetty should be made and no one allowed to get into the water.

(*g*) They should always have fish, especially of the smaller variety, which by feeding on mosquito larvæ and other organic impurities help to keep the water pure.

(*h*) No fishing or rowing should be allowed.

(*i*) Weeds should be removed as soon as they have grown, and the tank emptied and re-excavated whenever the water deteriorates in quality.

Except when the precautions given above can be strictly observed, tank water should not be used for drinking purposes.

Tank water deteriorates in the hot weather from putrefactive changes and improves during the rains by dilution with rain water. Tanks for water-supply in course of time become stocked with water plants, and the annual decay of the plants gradually forms a layer of very offensive mud at the bottom. Certain filamentous green weeds, having the same specific gravity as water, float in layers of several feet in depth and when they die, sink, and give off H_2S.

VII. **Rivers and Streams.**—River water is a mixture of surface and spring water. and usually contains the impurities to be found in both of them. Rivers and streams are the natural sewers of the regions they drain and are therefore highly polluted. In India rivers furnish the chief sources of water supply. Where the flow of water in a river is enormous compared with the volume of polluting matter entering, and the water is impounded in reservoirs for subsidence, and the clarified water is finally subjected to most careful filtration, a good potable water may be the result. Water from large streams if properly looked after is a good source of water for town supply. Towns, as a rule, draw their water-supply from a river above the spot where the sewage of the town is discharged. But large rivers are able to get rid of a moderate amount of sewage pollution by the combined agencies of oxidation, vegetation, and bacterial action.

The danger of pollution in rivers is from sewage, manuring cultivated fields, and trade effluents. The analysis of Ganges water below Cawnpur proved that 18 miles below the city sewage was still found in the water.

Corpses are thrown in without burning, and the bodies are torn to pieces by carrion birds, leaving the contents of the stomach and intestine to mingle with the water, while the people wash, drink the water and carry away jars full of it for home consumption.

Streams and rivers in their course through cultivated areas, towns and villages often take up impurities derived from sewage and industrial effluents, particularly near the banks, and therefore such waters should be looked upon as unsafe for drinking purposes. The composition of river water varies much according to the part of the river whence it is taken. As a rule river water is softer than ground water, but contains a large amount of organic matter. Near the source the water is comparatively purer, but the impurities increase as it descends.

Many rivers either completely or partially dry up during summer and the bed of the river is fouled with human and animal excreta.

In India most of the places for pilgrimage are situated on the banks of the rivers and the popular custom of bathing in the river by hundreds makes the water positively dangerous for drinking purposes.

Water for drinking purposes should therefore be collected a few feet from the shore. This may be done by means of a small boat tied to a post or anchor, or by having a sort of a jetty-like arrangement, or by means of a pipe attached to a hand-pump. In India many rivers remain dry for a greater part of the year, and the water can be impounded by erecting a high dam across the bed of the river.

VIII. **Distilled Water.**—Distilled water is generally resorted to on shipboard and is often obtained from sea water. This is usually flat and not very palatable, and should therefore be aerated before using. Distilled water should never be stored in zinc, lead or copper vessels.

Storage and Delivery of Water

Storage of Water.—It is generally necessary to store water, but the methods vary with the source. In upland

surface schemes storage is usually made by impounding the water. By this method large artificial lakes are often formed which should hold enough water to supply a town for some time. The size of such reservoirs depends on the area of land and the number of population requiring the water. Large towns are often divided into districts, each of which has a service reservoir. This system has an advantage: in case of disorder or waste in one district other districts do not suffer in consequence thereof.

In the case of water-supply of a town or a city it is necessary to provide large storage reservoirs the capacity of which should be such as to hold at least a week's supply. For small communities, such as prisons or asylums, deep wells or deep tube wells are quite useful. In villages and rural districts shallow wells and tanks are often the only sources of supply.

Action of Water on Lead.—The kinds of water which affect lead most are the best and the worst waters.

The following kinds of water act on lead :—

1. The purest and most highly oxygenated water, as rain and upland surface water.
2. Water containing nitrates or nitrites (sewage and animal matters) or chlorides.
3. Water from peaty soils containing acids, as humic acid.
4. Neutral distilled water.
5. Muddy river water.

Water containing one-tenth of a grain of lead in a gallon is unfit for drinking purposes. Filtration through charcoal will remove lead from water.

Waters least likely to affect lead are :—

1. Hard water, containing sulphates, carbonates, and phosphates of calcium, forms a coating of insoluble carbonate of lead in the interior of the pipe which prevents further action.

Hard water containing carbonic acid gas under pressure would dissolve a small amount of carbonate of lead. This explains cases of lead poisoning from soda water.

2. Water containing soluble silica deposit, silicate of lead being insoluble in water.

Distribution of water.—In Indian towns filtered water is usually delivered by means of iron pipes laid underground. To avoid erosion, particularly when the water is soft, these are coated either with Angus Smith solution, or vitreous glaze to protect them from the injurious effect of water. In Calcutta distribution is carried on by steel pipes $\frac{3}{4}$ in. thick coated with a special asphalt preparation and having a diameter of 5 ft. to 6 ft. Galvanised iron pipes are better as they do not rust as plain iron pipes. Temptation to use lead pipes in houses is great as they are easily bent and fitted and comparatively cheap ; whereas iron pipes require joints at frequent intervals and at every angles and bends. These are connected with the main through brass ferrules.

In the distribution of water it is essential that not only the poorest and least sanitary parts of a town be well supplied, but there must be a proper water-supply to dairies and cattle-sheds, or else the vessels used for milk will be washed in any collection of water available, very often in water highly contaminated by cattle or washings from cattle-sheds.

For many purposes for which water is used it is not absolutely necessary that the water should be pure. Where the demand is great, as in large towns like Calcutta, and owing to a deficiency in the amount of pure water available, there is a dual system of supply—the impure or unfiltered water for flushing sewers and water-closets, watering roads, extinguishing fires, and for manufacturing or trade purposes ; and the pure for drinking and cooking purposes. With this dual supply the amount of pure water required is greatly lessened. In villages this double supply is very commonly met with. The well yields water for cooking and drinking purposes, whereas a neighbouring stream, tank or pond furnishes water for washing, bathing, etc. There can be very little objection to such a procedure in villages, but in towns a dual supply necessarily involves a second system of mains and supply pipes, and very often impure water will be used for drink-

ing purposes and may thus be a factor in spreading water-borne diseases.

Water-supply in towns may be either *intermittent* or *constant.* In many towns for the sake of economy the supply of water is intermittent. In theory this method appears economical but in practice it leads to little, if any, saving. In the intervals during which the mains and service pipes remain empty, foul air and polluting matter from sewage-charged soil or drains are liable to be sucked in through imperfect joints or decaying pipes. Larger house cisterns have to be provided for storage of water, which is often wasted. There is further the risk of contamination, and as the whole day's supply has to be furnished in a few hours, large mains are necessary. In cases of fire water may not always be available.

Properties and Impurities of Water

Properties of Water.—Water is a clear, transparent, tasteless, and odourless liquid. It freezes at 0° C. or 32° F. ; and in freezing increases in bulk by one-eleventh of its original size. Its greatest density is at 4° C. It is very slightly compressible, and boils at 212° F. or 100° C. under a pressure of 760 mm., when it is converted into more than 1600 times its own volume of steam. The boiling-point varies according to pressure, and at Darjeeling which is about 7000 ft. above sea level, it is 96° C. It is a chemical compound, consisting of two volumes of hydrogen and one of oxygen.

Impurities of Water.—According to Parkes, the origin of impurities may be from :—

(*a*) *Substances received at the source.*—The character of the water will depend upon the geological structures through which it has travelled. The presence of calcium or iron will produce hard water as in chalk wells. Water from the neighbourhood of graveyards contains organic impurities. Likewise, water from wells in towns or densely populated places often contains calcium, sodium, nitrites, nitrates, sulphates, phosphates, etc.

Water, either in wells or tanks, may often become contaminated by soakage and washings. Very often slop water from village houses is conveyed by pervious drains to the nearest tanks, thus contaminating the water to a dangerous degree. In India the tank water is very often contaminated by washing clothes in or near the tank and the passage of excrement directly into it. A village tank, therefore, is a great source of danger, and a strict eye should always be kept on such a water to prevent any form of pollution.

(*b*) *Impurities derived during transit from source to reservoirs.*—Open conduits like rivers, canals, etc., are liable to be polluted by sewage, house and waste water, manufacturing refuse, etc. Purification, however, goes on during its flow by means of subsidence, by the action of normal water bacteria on pathogenic micro-organisms, and by the presence of aquatic plants. (*See* Natural Purification of Water.)

(*c*) *Impurities from storage.*—When water is obtained from a tank or well or in a town where the supply is intermittent, it is necessary to store water for drinking purposes ; but the method of doing so is by no means unimportant, for however carefully the water may be stored it often deteriorates, and by losing its sparkling character gradually becomes flat and insipid.

In this country water is ordinarily stored in *ghurras* or metal vessels, wooden tubs and masonry tanks (*choubachhas*), etc. When stored in metal vessels and protected by a cover the water, although it partly loses its aerated character, remains pure. *Sarais* and other earthenware vessels have the advantage of keeping the water cool and sparkling, but being porous they take up dirt and may therefore contaminate the water. These receptacles are very often kept under staircases, on landing floors, and in other insanitary places where accidental contamination from dust, dirt, cockroaches, etc., are liable to occur.

(*d*) *Impurities of distribution.*—Lead and other metals are dissolved by certain waters, and if the pipes are occasionally left empty, as happens when the supply is inter-

mittent, sewage and impure air may be drawn into them through leaky joints or cracks. This may be prevented by laying the water mains at a distance from gas pipes, drains or sewers, and on a solid basis so as to prevent any cracks occurring from subsidence.

The distribution of water is sometimes carried on by *bhistis* (water carriers) in *mussaks* or leather bags ; these can hardly be kept clean and the chance of contamination therefore greatly increases. These water carriers as a rule live under insanitary conditions and the *mussak*, if once becomes infected, will act as a focus for spreading the contamination. This mode of transport is unfortunately still in existence even in Calcutta, and should be discountenanced, and whenever such water is utilised for drinking purposes it must always be boiled.

Effects of Impurities of Water

Contaminated water may often be used for a lengthened period without giving rise to any appreciable effect on the consumers, and it is very probable that in many instances the system becomes habituated to its use. For, not infrequently, we find persons who are used to pure water suffer from some trouble when they drink polluted water, which the old inhabitants of villages prefer drinking to a purer supply. But impurity to a certain extent is practically inevitable and is neither disagreeable to the taste nor injurious to the health. An absolutely pure water is insipid and perhaps unwholesome. A good water is not one which is chemically pure. Transparent, colourless, odourless, tasteless water with no suspended matter or excess of total solids, but with sufficient dissolved air, is all that is wanted.

Certain diseases like cholera, typhoid fever, dysentery, etc., having their primary seat in the alimentary canal are carried through infected water used for drinking purposes. Water is occasionally responsible for carrying animal parasites, amœbæ and worms. It may give rise to lead poisoning and bring about derangements of metabolism resulting in such condition as goitre. The greatest

danger in water is pollution from human sources. Since water is used raw as compared to other foods which are cooked it is one of the most common sources of infection.

I. **Effects of Vegetable Impurities.**—Putrid or decaying vegetable matters may give rise to diarrhœa and dysentery and other severe symptoms to persons unused to it.

II. **Effects of Mineral Impurities.**—Suspended mineral matters or an excessive quantity of magnesium sulphate or chloride may cause irritation and set up *diarrhœa*. *Sprue* is not an uncommon affection in certain parts of India, and it has been ascribed to fine particles of mica in suspension.

Plumbism.—This may result from the continued use of water containing lead. This metal is seldom found as a normal constituent of natural water, but soft waters act on lead pipes, cisterns, etc. One-tenth of a grain per gallon has been known to produce ill effects.

Zinc is occasionally found in water, and soft water which acts on lead will also dissolve a certain amount of zinc from the surface of galvanised iron. Obstinate *constipation* may result from the consumption of such water.

Iron is not infrequently found in water and gives rise to dyspepsia.

III. **Effects of Animal Impurities.**—The principal diseases of man contracted by drinking infected water are typhoid fever, cholera and dysentery. These play an important part in the tropical countries. In all cases the water is infected directly, and therefore tanks and rivers are largely responsible for the outbreaks of epidemics.

Cholera.—Water plays a most important part in the spread of this disease. In India villages on the banks of rivers are especially affected. Outbreaks also occur when the tank or well, which supplies the people with

drinking water, becomes infected. Epidemics are not uncommon in a pilgrimage or after a bathing festival.

Goitre.—The primary cause according to McCarrison is a micro-organism which in the intestine of man produces a toxin having special effect on the thyroid gland which enlarges. The exact nature of the organism has not yet been identified, but it appears to be present in the soil of goiterous regions, whence they are carried to man through water.

Typhoid Fever.—This is propagated through water infected by the urine or fæces of patients who are suffering or have suffered from, typhoid fever.

Entozoal Diseases.—Diseases due to *Distoma hepaticum*, *Ascaris lumbricoides*, *Filaria sanguinis hominis*, *Ankylostoma duodenale*, *Oxyuris vermicularis*, *Tænia solium*, etc., may be contracted by drinking water containing the ova of these parasites.

Purification of Water

A public water-supply should be of such a nature as will not require further purification by its consumers. Water derived from carefully protected springs or deep wells needs no such treatment, but in the case of surface water, river water, or water from any source liable to sewage contamination, purification becomes necessary.

In public water supply the primary object of purification is to remove from the water any traces of pollution that may give rise to disease. It is also desirable to remove suspended matter for æsthetic purposes, and dissolved mineral matter to render the water suitable for manufacturing or domestic purposes, *i.e.* render it soft.

The principal methods employed for the purification of water on a large scale are (1) storage, (2) filtration, and (3) chemicals. But no method of purification can be considered satisfactory from a sanitary point of view that does not eliminate water-borne diseases.

Impure water may be purified by either of the following methods :—

A. Natural

B. Artificial
- I. Physical :
  - *a.* Distillation
  - *b.* Boiling
- II. Chemical :
  - *a.* Precipitation
  - *b.* Germicides
- III. Filtration :
  - *a.* Slow sand filters
  - *b.* Rapid filters (mechanical)

A. Natural Purification of Water.—This is only possible in the case of rivers and streams, or where there is a large volume of water ; for as soon as any sewage or polluting matter enters the water it becomes diluted, and the dissolved oxygen, through the agency of aerobic bacteria, oxidises to a certain extent the organic materials of the sewage, and consequently the water absorbs more oxygen from the air to replace this loss. Aquatic plants give off oxygen, and unless these are destroyed by sewage further oxidation occurs. Moreover, fish and other lower forms of animal and vegetable life which exist in large numbers in certain water help the purification by feeding on these organic impurities, and if the current is sluggish the suspended matters settle to the bottom. Indeed Delépine has shown that this sedimentation is an important factor in the bacterial purification of river water. Further, the solar rays aid materially in the purification of such water. Yet of greater importance is the evidence of destructive changes accompanied by the loss of virulence which certain organisms particularly those of an " intestinal type " undergo in river and stream waters. These organisms are *B. coli*, *B. entertidis sporogenes*, etc. It seems probable that water is not the natural habitat of pathogenic bacteria as of cholera and typhoid fever. In the struggle for existence they have to fight against the saprophytic bacteria present in water.

B. Artificial Purification of Water :—

I. Physical Method or Sterilisation of Water by Heat.— There are two ways of doing this :—

(*a*) *Distillation.*—By this method water is rendered pure in a chemical sense. But from a practical and economical point of view it has several objections. It is not practicable to do this on a large scale. Distilled water has a flat taste, suggestive of scorched organic matter and it acts on metals.

(*b*) *Boiling.*—By this means certain micro-organisms are destroyed, the temporary hardness of water is removed by the precipitation of calcium salts, ammonia and sulphuretted hydrogen gases are given off. The spore-forming microbes are resistant to boiling water, unless time is allowed for the development of the spores. Boiling makes the water very flat and insipid, and it should therefore be aerated before drinking.

II. Purification by Chemical and other Agents :—

(*a*) *Use of Precipitants.*—By these a precipitate is formed which entangles and carries down suspended matters and micro-organisms. The following are the different methods :—

1. *Softening of Water.*—A hard water is that in which calcium and magnesium salts are held in solution in the form of carbonates and sulphates. When the hardness is due to the presence of carbonates of lime and magnesia kept in solution by carbonic acid, it is known as *temporary*, as the hardness is removed by boiling which drives away CO_2 gas and thus precipitates the carbonates. When the hardness is due to the presence of sulphates and not dependent on the presence of CO_2 and therefore not removed by boiling it is called *permanent*. When hard water is used in the water-supply of a city, as for instance London, where the water is derived from chalk stones, it is necessary to soften the same. As it is not practicable to boil the water on such a large scale, this is done by adding for every 100,000 gallons of water 6 lbs. of freshly burned lime for each degree of hardness. The lime combines with CO_2 holding the chalk in solution and the

calcium carbonate is precipitated. This process of softening water is known as Clark's process. Permanent hardness due to the presence of sulphates of calcium or magnesium is removed by the addition of lime and soda either in the form of hydrate or carbonate, thus

$$CaSO_4+Na_2CO_3=CaCO_3+Na_2SO_4$$
$$MgSO_4+Na_2CO_3=MgCO_3+Na_2SO_4.$$
$$CaCO_3,CO_2+CaO=2CaCO_3$$

2. *Alum.*—This acts if the water contains calcium carbonate. The action of alum is purely mechanical and depends upon the fact that alkaline carbonates combine with it and form aluminium hydrate. As it has a large colloidal molecule and being insoluble, it forms a flocculent precipitate, which entangles suspended impurities and bacteria. The usual quantity required is 6 grs. to a gallon. Alumino-ferri 1 gr. to the gallon is very widely used nowadays. This is more efficient though costly.

The clarifying effect is more marked if 5 grs. of lime are added after the alum. Alum also has the property of destroying water bacteria. ½ gr. to a gallon has been shown to reduce 8000 micro-organisms in 1 c.c. of water to 80. Although alum has such a remarkable destructive power over water bacteria it does not destroy even in greater strength the typhoid or cholera organisms.

3. *Perchloride of Iron.*—2½ grs. to a gallon will purify water from its suspended organic matter and clay.

4. The fruit of *Strychnos potatorum*, commonly known as " clearing nut " (*neermuli*, vern.), is used in India to clear muddy water. One of these fruits is well rubbed for a minute or so on the inside of the vessel containing the water, which is then left to settle. In a very short time the impurities fall to the bottom leaving the water clear.

(*b*) *Germicides.*—The following are the common germicides used to purify water :—

1. *Potassium Permanganate* acts mainly as a germicide by destroying the organic matter on which bacteria thrive. It is specially useful for sterilising relatively small

quantities of water, *e.g.*, of wells and cisterns. In proportion of 5 parts per million it removes 98 p.c. of bacteria in 4 to 6 hours. It is rather expensive and is not suitable for sterilising large volumes of water as of tanks. The best way to employ it is to prepare a solution of a definite strength so that the required amount can be measured. After further dilution this can be poured into the well etc., and thoroughly mixed up with water. Usually 1 dr. is required for a well 2ft. in diameter and containing about 8ft. of water. The amount can also be gauged by the colour test, a sufficient quantity is added to the water of a well to give it a faintly perceptible pink tinge after the lapse of several hours.

2. *Lime.*—Quicklime has long been used for the treatment of polluted water, and Houston has demonstrated that in certain circumstances it is a most effective agent for this purpose. To be effective, good quick-lime or water-slaked lime is necessary. Whiting, air-slaked-lime, chalk and carbonate of lime are useless. It is cheap and easily available. The amount required varies with the character, hardness, etc., of the water to be treated. A fifty feet square tank requires about 14 pounds.

3. *Copper sulphate* is useful for removing algæ and other vegetable growths in tanks. A solution of 1 in 200,000 is necessary to be of any use. It combines with the bodies of the micro-organisms and settles to the bottom. If the water is afterwards filtered most of the remaining copper is removed. The simplest way to ensure a thorough diffusion of the reagent is to put it in linen bags attached to ropes or strings and then draw them through the water to be treated.

4. *Nesfield's Tablets.*—A two-grain tablet of iodide-iodate of soda and the same quantity of citric acid is added to four gallons of water, and it is claimed that cholera and enteric organisms are killed in a few minutes.

5. *Bleaching Powder.*—This is made by saturating slaked lime with chlorine at ordinary temperature, and is very efficacious in sterilising drinking water. It is found in whitish powder or in friable lumps with a feeble odour of chlorine and a disagreeble bitter saline taste.

Unlike many other powerful disinfecting agents bleaching powder and solutions of hypochlorites may be used safely for sterilising water for drinking purposes.

The amount required to effectively sterilise water varies with the composition of water. The more organic matter the water contains the more bleaching powder is necessary. This method is cheap, reliable, efficient, easily applied and harmless, and when added in proper proportion leaves no undesirable chemical substance in the water.

Bleaching powder of good quality should not contain less than 25 p.c. of chlorine. Forty pounds of this strength added to a million gallons of water give a proportion of available chlorine equal to one in a million parts. With bleaching powder of lower strengths, proportionately increasing amounts are needed to give the same result. Thus :—

Bleaching powder containing 20 p.c. chlorine would require 50 lbs. per million gallons ; 15 p. c. would require 67 lbs. : 10 p. c., 100 lbs., etc.

The student should also remember that 1 oz. of chlorinated lime (25 p. c. strength) added to a well 8 ft. in diameter and containing 5 ft. of water will give approximately 1 in a million available chlorine.

To calculate the amount of water available in a well the following formula is helpful, *viz.*—

$D^2 \times W \times 5$ = number of gallons of water in well.

D = diameter of well in feet.

W = depth of water in feet.

To find the number of gallons of water in a well 6 ft. diameter and containg 10 ft. of water would be

$$6 \times 6 \times 10 \times 5 = 1{,}800 \text{ gallons.}$$

6. *Ozone.*—Being a powerful germicide ozone is one of the most satisfactory methods of purifying water, as it makes the water practically sterile and oxidises the organic matter. It has however no effect on resistant forms of spores, but these are harmless when taken by the mouth. Ozone does not clarify the water and has no effect on mineral salts. It is therefore necessary to clarify the water before applying ozone.

Ozone is produced by electrical discharges in the atmosphere, and this ozonised air is brought into contact with water. It requires 1 to 3 mgrms. to purify 1 litre of water. But owing to the expense and the electrical and engineering difficulties involved this process is not so suitable for the purification of water on a small scale.

7. *The Ultra-Violet Rays.*—Sterilisation of water by *ultra-violet rays* is being largely used on the Continent. The beneficent effect of sunlight in purifying water is believed to be due to the *ultra-violet rays*, and a special apparatus has been made to purify large volumes of water by subjecting it to these rays. It has been found that an exposure of twenty seconds will kill *B. coli* and about thirty to sixty seconds *B. subtilis*. The chief feature of the apparatus is the immersion of a mercury vapour quartz lamp producing ultra-violet rays in a current of water.

It should be observed that the above methods of purification of water are anything but satisfactory. Purification by *boiling* is by far the safest, and is therefore recommended for general use where filtered water is not available.

III. **Filtration.**—Filtration on a large scale is accomplished in different ways, the most common method being by means of sand filter beds, either in the form of slow sand filters, or in small tanks, as in the so-called rapid or mechanical filters.

(*a*) *Slow sand filtration.*—These filters consist of large, shallow reservoirs containing sand and gravel as filtering media, and the water is passed through them slowly from above downwards. This process is called slow filtration in contra-distinction to the rapid filtration.

These water filters require extensive tracts of land and are therefore usually situated in the outskirts of the city and located on the bank of a river or stream. As it is not desirable to run the water directly into the filter beds which may cause choking or clogging of the filters, the water, taken from the stream where there is no source of pollution within a reasonable distance, is first collected in *settling tanks* or large reservoirs where sedimentation

occurs and most of the bacteria are destroyed by light and air. This sedimentation is the first step of filtration, and may be simple sedimentation or sedimentation with the addition of a coagulant. In the former process it takes about 24 to 48 hours for the suspended impurities to settle specially during the rains. The use of a coagulant helps sedimentation to take place more quickly ; and the usual coagulant employed is sulphate of alumina.

Houston claims that this sedimentation has a considerable influence on the bacterial life. The number of bacteria is reduced often by 99 per cent., the bacteriological ratio of water is altered by the reduction of the B. coli to a greater extent than other water bacteria, and the typhoid and cholera organisms are devitalized. All these have a marked "levelling" effect on water before it is allowed to pass into what are called "filter beds."

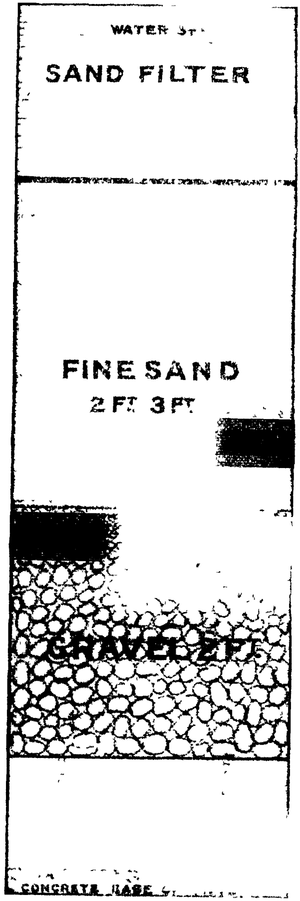


FIG. 3.—SECTION OF A SAND FILTER.

Filter Beds.—These are water-tight reservoirs, rectangular in shape arranged side by side in rows, either open or covered. The depth should be 9 to 10 ft., sufficient to contain the necessary filtering materials and water and leave a margin of 2 to 3 ft. above the surface of the water. They should have perforated tubular drains below for the collection of

the filtered water, and are filled from below upwards with :—

(*i*) Two layers of *bricks* arranged in the form of channels for the passage of water, spaces being left between two bricks, which are covered by the second layer (*see* Fig. 3).

(*ii*) *Gravel* from 6 in. to 2 ft. deep, of varying coarseness which increases from above downwards. The function of this layer being mainly as a support for the upper layer which consists of sand from 2 ft. to 3 ft. in thickness.

The effect of this filtration is chiefly mechanical, although a certain amount of biological action does take place. The suspended impurities are strained off by the upper portion of the filter, and a certain degree of oxidation of organic matter is effected by the aid of nitrifying organisms. The real agent which separates the organisms is the layer of slimy organic matter known as the "vital layer" formed upon the surface and in the interstices of the sand. This green slimy layer made up of fungi, algæ, and other low vegetable organisms, commences to appear after three days; and therefore the filter acts best after the third day when this jelly-like layer or membrane is formed. The bacteria get entangled and arrested by this gelatinous mass and so are prevented from passing down into the deeper layers of sand and gravel. Koch has shown that if this surface be removed by scraping, or its continuity affected in any way as by excessive and irregular pressure, the number of bacteria which pass through this purifying layer will increase considerably. When, however, this deposit becomes very thick and consequently impermeable, filtration becomes imperfect and the bed has to be scraped, washed, and cleaned, but after this water should be allowed to stand till a fresh membrane forms before filtration commences again; therefore the first portion of the water should not be stored in the pure water reservoir. At each scraping about a quarter to half an inch of the sand is removed, and when, by repeated cleaning, the thickness of the layer of sand is reduced to about 16 in. the filter is

thrown out of action and the bed has to be renewed to its original depth. The most important in these filters is the rate of filtration. Ordinarily it should run at a rate of 2,500,000 to 3,000,000 gallons per acre per day. When it passes at the rate of 4,800,000 gallons per acre daily it has a vertical movement of 3.94 inches per hour. If however hypochlorite is added to the water one can increase the rate of the filter. The effluent from each filter should not yield more than 100 microbes per c.c. on gelatin plates, and the thickness of sand should never be less than 11.8 in. Nowadays the gravel layer is reduced and the layer of sand made thick.

Taken as a whole sand filtration involves four distinct stages, as follows :—

1. The sedimentation of the grosser particles in the settling tanks.

2. Mechanical obstruction to impurities in the interstices of the filter.

3. Oxidation of the organic matter in the pores of the filter beds.

4. Process of nitrification carried on by the micro-organisms in the vital layer on the surface of the filter.

An essentially bad water cannot be made good by any amount of filtration, therefore no attempt should be made to purify organically impure water for drinking purposes.

The other method of slow sand filtration is by the *Puech-Chabal System*. In this system the clarification and purification are accomplished by passing the water through successive layers of gravel, graded from coarse to fine, before it reaches the final slow sand filters.

(*b*) *Mechanical Filters.*—The mechanical or rapid filters include all types of filters that are worked at a rate of flow forty to sixty times greater than that which is usually permitted in the slow sand filters. They include Jewell, Paterson, and Bell's filters. With the growth of population and in expanding cities it is found that slow sand filters do not adequately meet the increasing demand for filter water. These filters have therefore replaced in many places the slow sand filters. In this

process of rapid filtration three steps are involved, viz. *coagulation*, *sedimentation* and *filtration*.

There are many types of mechanical filters but the following may be taken as a typical cycle of operation.

Raw water is led continuously into the plant and the requisite dose of coagulant (aluminium sulphate 1 to 4 grs. per gallon of water) introduced in solution by means of special gear. The water then passes down a pipe or mixing trough where the coagulant is well mixed and reacts with the calcium bicarbonate (temporary hardness or alkalinity) in the water, forming hydrate of aluminium, a finely divided gelatinous precipitate as follows :—

$$Al_2(SO_4)_2+3CaCO_3+3H_2O=Al_2(OH)_6+3CaSO_4+3CO_2.$$

The treated water flows into a coagulating tank where partial precipitation takes place during its passage from one side to the other, which occupies a varying period according to the nature of the water.

The partially settled water with about 20 per cent. of gelatinous precipitate still in suspension is then admitted to a series of rapid filters. The effluent from the filters then passes through automatic regulating gear and is sometimes sterilised by chlorine gas on its way to the pure water reservoir.

When the filter becomes clogged the sand is violently agitated by means of rakes, compressed air or steam, and filtered wash water is admitted from the bottom and flows away to waste over the top carrying with it the dirty gelatinous film.

After washing a new film is formed (this can be done in five minutes) and a filter which has become clogged up can be washed, filmed and ready for service 15 minutes after.

About 90 per cent. of the settlement takes place in the coagulating tank and the precipitate, which has absorbed the fine silt and colloidal matter, is periodically washed away through sludge pipes.

After washing a filter it is advisable to turn on a small quantity of alum solution to enable the filtering

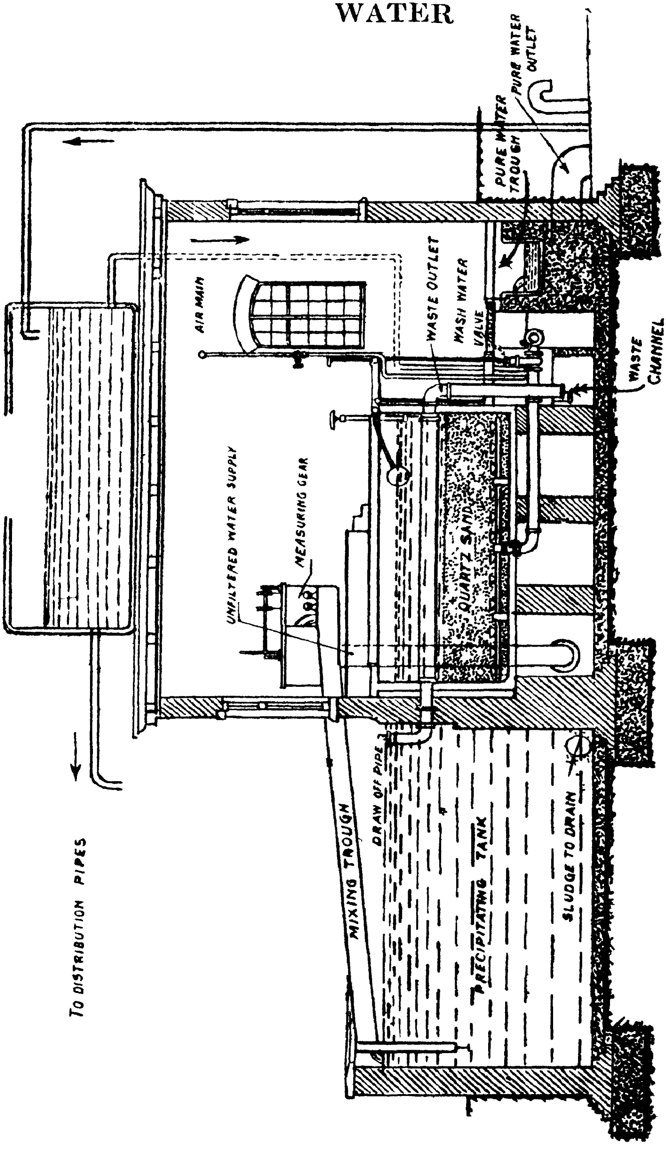


FIG. 4.—Section of Paterson's, Rapid Filter.

film to be formed quickly. 5 lb. of sulphate of alumina will carpet a filter 18 ft. ×10 ft., *i.e.*, 180 sq. ft., and forms the initial film which is then continually built up by the incoming water.

The Paterson system of rapid filtration comprises four distinct processes :—

1. *Addition of Chemicals.*—The automatic measurement of the raw inlet water and the addition of sulphate of alumina solution in proportion to the flow, is effected by the chemical measuring gear.

2. *Mixing of Chemicals.*—The treated water passes down a mixing trough provided with baffle plates where the solution of alum is mixed thoroughly with raw water.

3. *Coagulation and Sedimentation.*—This is effected in the coagulation tanks where most of the suspended and colloidal matters are precipitated and run off to waste through sludge pipes.

4. *Filtration.*—The removal of the coagulated impupurities and bacteria by rapid filtration.

The filtering film is composed of hydrate of alumina which coats the sand grains on the top of the filter, completely sealing up the interstices and preventing the passage of bacteria, colouring and suspended matter, whilst permitting the free passage of water.

Besides the mechanical property of entangling bacteria and suspended matter hydrate of alumina fixes the colouring matter, rendering it insoluble, and so effects decoloration and precipitation. This results in the entire removal of colour from peaty water, a result impossible to obtain by slow sand filtration.

After the addition of the coagulant the treated water is made to pass through coagulating tanks and the period of passage may be variable, depending on the state of the water and the time of the year.

The operation of washing is done as under :—

The inlet valve is shut off and the level of water in the filter is gradually lowered until it is automatically shut off by a ball valve. The outlet valve is then closed and the waste valve above the filter is opened. Air at about 15 lb. per square inch is then admitted from the

bottom of the filter and rises through the sand, agitating the bed thoroughly.

This agitation continues for 1 or 2 minutes according to the season of year and is then shut off. Immediately after, pure wash water at about 40 feet head is admitted from the bottom and flows upwards through the sand and away to waste carrying with it the dirty film and other impurities. This washing is continued for from 1 to 3 minutes.

The waste valve is then closed and water from the coagulating tanks with a supplementary feed of sulphate of alumina is then admitted and the new film allowed to form while the effluent from the filter is run to waste for a few minutes before being admitted to the pure water channel. This channel opens into a well protected under-ground reservoir made of brick and cement and provided with openings for ventilation.

The advantages claimed for rapid filters are :—

1. Simplicity in construction and economy in operation.

2. Filtration is continuous.

3. The filtering material does not require changing, and is thoroughly cleaned in a few minutes.

4. It is cheap and efficient and therefore especially adapted to those cases where the cost of land is high, and where the water is too turbid as to require large settling tanks.

Chlorination of Municipal Water Supply

The treatment of municipal water-supply by chlorination is a modern process and was first used at Lincoln by Houston to disinfect the water works system which had become infected by typhoid organisms. Subsequently the use of chloride of lime for purification of water both by itself and in conjunction with filtration became very popular in America. During the last war it was used with much success. Indeed during the war the water-supply of London was chlorinated, primarily as an emergency measure, but successful and economi-

cal results obtained led to its adoption as a routine process.

√ For the treatment of water chlorine is usually utilised in one of the following forms :—(1) As a hypochlorite, such as bleaching powder ; (2) in the gaseous form ; and (3) as chloramine. Chlorination of water on a large scale can only be used economically when the labour required for mixing the solution is cheap. But unless under expert control the dosage will be irregular from either over dose or under dose.

Chloramine (NH_4Cl) produced by the interaction of ammonia and chlorinated lime is one of the most powerful germicides known, and is probably the cheapest form in which chlorine can be utilised for water treatment.

The dosage required depend upon a number of factors, most important being the purification desired, the amount of oxidisable matter present, the contact period, the temperature of the water, and the method of admixture. Further, if chlorination is used in conjunction with other forms of purification the dosage required will be smaller in proportion to the purification effected by the other process.

Chlorination and filtration.—1. Its initial cost is cheaper ; 1 to 5 p. c. of filtration plant of equal capacity and efficiency.

2. The maintenance cost is in the same ratio.

3. Chlorination provides positive protection against accidental infection.

The most economical method of purifying polluted supplies is to rely upon chlorination for bacteriological purification and depend upon filtration for the removal of turbidity, colour, etc. In this way slow sand filters could be operated at much higher rates, and the enlargement of purification works which would otherwise be necessitated by an increased population could be avoided.

Chlorine treatment should be regarded as supplementary process to, and not as a substitute for, filtration. Whenever possible the chlorine should be applied to the filtrate, because

(*a*) the filtered water has a more constant organic content than the raw supply, and the dose can be regulated better ;

(*b*) the amount of chlorine is considerably reduced ; and ; therefore

(*c*) does not impart any taste to the water.

Domestic Filters.—For this purpose different materials such as animal or vegetable charcoal, silicated carbon, spongy iron, flannel, wool, sponge, etc., are used. Water filtered through animal charcoal favours the growth of microbes and deteriorates rapidly. The same remark holds good as to the majority of substances just mentioned. Spongy iron is the least objectionable of all.

A domestic filter to be satisfactory must keep back all germs, and the substances that are used for the purpose are some forms of infusorial earth, clay, porcelain, or patent combinations of porcelain and clay.

The essential features for a good filter are :—

1. It should be strong and compact and simple in construction to allow of easy cleansing and re-adjustment.

2. It should be constructed of some stable and efficient material having the power to purify water to a high degree.

3. The filtering medium should not require frequent changing, and neither it nor the receptacle should impart anything injurious to the water.

4. It should be cheap and its purifying power fairly lasting.

The following domestic filters are commonly used :—

1. *The Pasteur-Chamberland Filter.*—It consists of porous tubes or bougies of unglazed porcelain made of kaolin. These tubes can be screwed on to a tap. Its action is purely mechanical, as it separates even very fine particles of suspended matters and bacteria. Unless there is some pressure the filter acts slowly ; 20 to 40 pounds of pressure per square inch will filter about three quarts of water per hour. The candles should be cleaned by brushing with hot water and then sterilised by boiling in water containing some sodium carbonate. It is a

perfectly reliable filter, as it frees water of all bacteria. Muddy water should first be cleared by passing it through closely packed coarse sponges and then filtered.

2. *The Berkefeld Filter.*—This consists of a cylinder made of infusorial earth ; but the cylinder wears thin by constant cleaning and gradually ceases to filter efficiently.

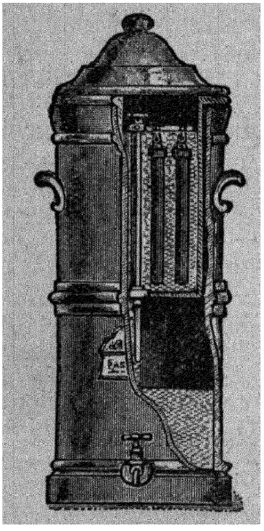


Fig. 5.—Pasteur-Chamberland Filter

In order to secure perfect protection from water-borne diseases, the candle should be sterilised by boiling every third day. Muddy water, if not previously clarified by passing through closely packed coarse sponges, would clog up such a filter rapidly. The sponges should, unless the water be very muddy, be cleansed and sterilised once a week.

Woodheads and Wood found that the only filters capable of completely removing organisms were the Pasteur Chamberland, Berkefeld and Porcelaine D'Amiante.

Of these two filters the Pasteur is more reliable and durable than the Berkefeld, but one disadvantage which may be urged against the Pasteur is that it filters very slowly and is practically useless unless the water is put under pressure. Horrocks has found that when sterile water is inoculated with typhoid bacilli and run daily through a Berkefeld filter, the bacilli appear in the filtrate in one to two weeks ; this is not the case with the Pasteur. The Berkefeld, on the other hand, requires no additional pressure and is more rapid in action, but the pores being more open, after it has been in use for a few days, may allow some organisms to appear in the filtrate. This, perhaps, is due rather to the growth of organisms in the pores of the filter-candles than to their direct passage.

Being made of infusorial earth they are more liable to fracture.

3. *The Four-ghurra Filter.*—This method of filtration is very popular in India and is resorted to by people living in villages. It consists of four unglazed earthenware vessels placed one over the other on a wooden frame, each one having one or more holes at the bottom stuffed with cotton-wool or straw. The uppermost one contains the unfiltered water which is strained through muslin. The second one is half filled with powdered charcoal, and the third one with fine sand and a layer of small stones underneath. The lowest one is the receiving vessel. The filtering media must be kept as clean as possible, and the charcoal should be renewed once every week or ten days, and the sand cleaned and dried once a month. This domestic filter is largely used in villages, but it is not without its dangers.

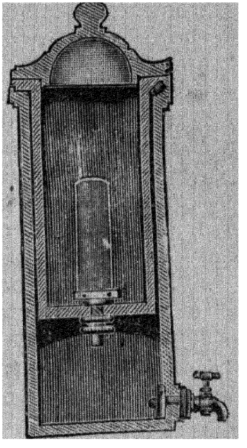


FIG. 6.—BERKEFELD FILTER.

The idea that domestic filters do not require any attention or cleansing and that the filtered water is always above suspicion is erroneous. For the pores of the filter very often get clogged with foul materials which afford a suitable nidus for bacteria to flourish in, and the so-called filtered water becomes decidedly worse than the original one. This happens particularly when animal charcoal is used as a filtering medium.

EXAMINATION OF WATER

For hygienic purposes the examination of water is generally done under the following heads :—

A. Physical or macroscopic examination.
B. Chemical examination.
C. Microscopical examination.
D. Bacteriological examination.

Collection of Sample.—Take a clean Winchester quart bottle of white or pale green colour with a stopper or a perfectly new and clean cork. Rinse it three or four times with the water to be examined. If the sample has to be taken from a stream, lake, or well, the stopper should be inserted and the bottle placed well under the surface of the water and then filled with water. In rivers, take from mid-stream or at a reasonable distance from the shore. In towns the sample should be taken from the mains or stand posts or taps. When collecting from a tap, allow the water to run for a few minutes before taking the sample. Fill the bottle quite full and replace the stopper which will make room for itself.

No sealing wax or grease should be applied to the stopper. It is best secured by a covering of clean linen or by an india-rubber cap and then sealed.

The bottle should be kept in a cool dark place, if possible in an ice box. The examination should be undertaken as early as possible after the collection of the sample.

The following informations should always be furnished with the sample of water :—

(*a*) Source of water, *i.e.* whether from tank, or well, etc.

(*b*) Geological formations of the neighbourhood ; so far as known.

(*c*) In case of a well, its depth, diameter, strata through which sunk, how used, and depth of the water.

(*d*) Possibility of impurities reaching the water ; in case of a well its distance from cultivated land, cesspools, drains, privies, etc.

(*e*) In case of surface or rain water, method in which the water is stored.

(*f*) Meteorological conditions, whether there has been any recent rain or flood.

(*g*) A statement of any existing water-borne disease in the neighbourhood, or special reasons for requiring analysis.

Each bottle should be distinctly labelled to correspond with the official letter or invoice.

A. **Physical Examination of Water.**—This by itself cannot form a basis of opinion, but brilliant, clear, non-smelling, and highly aerated water is alone fit for human consumption. Note the following :—

(*a*) *Colour.*—Pour the water into a colourless glass tube about 2 ft. deep, placed on a white plate, and note the colour. The longer the tube the better is the colour noticed. Pure water has a bluish or greenish tinge. A yellow or brown colour generally indicates contamination with animal organic matter, mainly sewage, but may also be due to vegetable matter or salts of iron.

(*b*) *Clearness.*—Shake a small quantity of water and note whether it looks hazy or not. Heavy sediments rapidly fall to the bottom. Turbidity is generally due to clay or silt, minute particles of organic matter, micro-organisms, etc.

(*c*) *Lustre or brilliancy.*—Some water is distinctly dull or of slimy appearance. Clear and sparkling water contains CO_2 and air.

(*d*) *Taste and smell.*—Purest water is without any taste or smell. Gases held in solution and mineral matter impart the taste to most water. Any smell in water is objectionable and is chiefly due to the growth of algæ and protozoa. An offensive water in a well or tank indicates stagnation at the bottom or the presence of dead animals. Hydrogen sulphide and other inorganic compounds may also impart offensive odours to the water.

B. **Chemical Examination of Water :**—

(*a*) *Reaction.*—This is taken with litmus paper, or by dropping a solution of phenolphthalein which when added to water having the faintest trace of alkali will turn it a delicate pink. Acidity may be due to humic acid or CO_2, if due to the latter it will disappear on boiling. Alkalinity may be due to the presence of sodium, calcium or magnesium carbonates in solution.

(*b*) *Hardness.*—This is due to the presence of carbonates of calcium and magnesium held in solution as bicarbonate by the dissolved CO_2. A certain amount of hardness is removed by boiling. "Total hardness"

is that which is present before boiling, and that which remains after boiling is called "permanent hardness." The amount of hardness is generally expressed in degrees. Clarke's soap test is employed in determining the amount of hardness. This consists of a solution of soft soap in a mixture of methylated spirit and distilled water in the proportion of 4 and 6 respectively.

To determine Total Hardness.—Take 100 c.c. of water in a stoppered bottle, to this add soap solution from a burette with constant shaking till a sufficient lather is produced. The number of cubic centimetres of soap solution, used, minus 1, gives hardness per 100,000 parts.

Permanent Hardness.—Boil 100 c.c. of water for 15 or 20 minutes, filter and add distilled water to make up the loss by evaporation. The hardness is estimated as above.

Temporary Hardness.—The difference between the total and permanent hardness is the temporary hardness.

According to Clarke's tests each degree corresponds to the soap destroying power of 1 gr. of $CaCO_3$ in 1 gallon of water. When it is less than 10 degrees the water may be considered soft or moderately soft, when 10 to 15 degrees moderately hard, when 15 to 20 degrees hard, and over this figure very hard.

(*c*) *Chlorides* are always present in small quantities in all waters except distilled water, and give a white precipitate with a solution of nitrate of silver. The examination is done on a white porcelain dish and the water must be neutral or faintly alkaline. The silver nitrate solution is dropped into a measured quantity of water tinted a faint yellow by the previous addition of a few drops of a solution of chromate of potash. As long as there is chloride present in the water white precipitate of silver chloride is formed, but the moment the amount of soluble chloride is used up the liquid acquires a reddish tint from the formation of red silver chromate. Chlorides are derived from sea water or sewage (urine) or from salts in the soil. It is impossible to draw any inference as to sewage contamination from the presence of chlorides alone unless one knows how much chloride is ordinarily present in water from the same source. Al-

though sodium chloride is found in the urine, considerable pollution must take place before it can be detected by an increase of the chlorides.

(*d*) *Nitrites.*—The presence of nitrites is an indication of recent contamination by sewage undergoing decomposition; therefore water containing nitrites, except when not due to the presence of iron, should always be condemned. The presence of nitrites may also be due to the reduction of nitrates by ferrous salts. During the decomposition of nitrogenous organic matter, a large part of the nitrogen passes off in the gaseous state, the remainder combines with hydrogen to form ammonia. Their presence is detected by adding to 100 c.c. of the sample dilute sulphuric acid and a few drops of metaphenylinediamine, when a yellow colour is produced on standing.

(*e*) *Nitrates.*—Nitrates are the ultimate products of oxidation of all animal matters. If nitrates are large in amount and nitrites and ammonia are small, the import is that the water has been contaminated before and the ultimate product is left behind, or that the contamination occurred above the point of taking water. The presence of nitrates indicates that the contamination is of long standing. Sometimes their presence may be due to water which has permeated a stratum containing nitrites, *e.g.* oolite, red sandstone, etc. The nitrates and nitrites are never present in raw sewage, and if they are found with excess of ammonia it means that the water has been contaminated with sewage or animal refuse.

Test.—Evaporate a little of the water and to the residue add a drop of H_2SO_4 and a little brucine, when a pink colour is produced.

(*f*) *Ammonia* is detected by adding Nessler's solution, which gives a yellow or brown colour according to the amount present in the water. Sewage and manurial matter yield free ammonia on distillation, but by the action of an alkaline solution of potassium permanganate on the albuminous matter a further quantity of ammonia may be detected. This is called *organic or albuminoid ammonia*, as distinguished from *free or saline ammonia*. Traces of ammonia may be detected in almost all waters,

especially rain water; therefore its presence alone cannot be taken as an indication of animal pollution. Besides this, water which has been stored for some time in metal vessels will yield ammonia, due to the reduction of nitrate by the metal (as zinc, iron, lead). But in these cases traces of metal can be detected. These impurities absorb much oxygen from an acid solution of potassium permanganate, called "oxygen absorbed." The amount of free and albuminoid ammonia and of "oxygen absorbed" should be considered together in forming an opinion as to the purity of water.

Tests.—(i) *Free Ammonia.*—Place 250 c.c. of water in a boiling flask and distil over 50 c.c. The amount of ammonia is determined by the process of "Nesslerisation," which consists in adding to the distillate 2 c.c. of Nessler's solution, and imitating the depth of colour produced by adding Nessler's solution to pure distilled water to which definite quantities of solution of ammonium chloride has been added. The water remaining in the retort is used in the test of

(ii) *Albuminoid Ammonia.*—Distil over another 50 c.c. and pour into the distilled water bottle. Add 25 c.c. of alkaline potassium permanganate solution and distil off two 50 c.c. Nesslerise as before.

The amount of ammonia obtained in the above two experiments multiplied by 0.4 gives the ammonia in 100,000 parts of water.

(*g*) *Copper.*—To 100 c.c. of water add a few drops of acetic acid and 2 c.c. of a fresh solution of potassium ferrocyanide, when a chestnut-brown coloration is obtained.

(*h*) *Lead.*—If no reaction is obtained in the above for copper, test for lead. Take 100 c.c. of water, acidify with acetic acid and add a few drops of potassium chromate and stir. A yellow turbidity indicates the presence of lead. If lead is present in fair amount a yellow precipitate is obtained.

(*i*) *Iron.*—If neither copper nor lead is detected test for iron. Take 100 c.c. of water, add to it 5 c.c. each of nitric acid (1 in 5) and 10 per cent. solution of potassium

sulphocyanide. A red coloration indicates the presence of iron.

(*j*) *Total Solids in Water.*—Take a known quantity of water, say 100 c.c., and evaporate to dryness on a weighed platinum dish. Weigh the dish with the residue and the increase in weight is the weight of the solids. It is better after the evaporation to transfer the dish and its contents to an air-bath heated to about 250° F. by which the water residue is thoroughly dried. The basin is then withdrawn, rapidly cooled and weighed. Increase in weight is the weight of the solids. After weighing the perfectly dry residue, the contents may be gently ignited and any change of colour noticed. White incrustation indicates mineral matter, while charring indicates organic matter ; and the smell evolved may give a rough idea as to whether the organic matter is of animal or vegetable origin.

C. **Microscopical Examination of Water.**—This is best done by centrifugalising the water, when all its suspended matters fall to the bottom of the tube. The grosser matters, as clay or sand are easily recognised by boiling the water, when they sink rapidly to the bottom. Sediments can also be obtained by allowing the water to stand for some time in a conical vessel. Suspended sand or clay gives a yellowish white turbidity, sewage generally a light brown, and vegetable matters or peat a blackish colour. The presence of spores or mycelia is due to contamination with sewage, and the most suspicious elements are the remnants of vegetables used for food, *e.g.* spiral cells of cabbages, cauliflowers, etc. Detection of these cells, as also of fibres of cotton, linen, wool, hair, starch granules, etc., can be made under a microscope. The presence of a large number of parenchymatous tissues, spiral cells, and yellow elastic tissue indicates contamination with fæces. Animal substances, *e.g.* wool, hair, yellow elastic tissue, etc., generally indicate recent contamination, while sarcinæ ventriculi, a kind of alga growing in the stomach, point to sewage contamination.

D. **Bacteriological Examination of Water.**—It is well known that drinking-water may contain the germs of diseases like typhoid, cholera, and dysentery, usually

termed "water-borne." In Europe several epidemics of typhoid fever have been traced to drinking infected water, and in India thousands die every year of cholera by drinking water containing the specific germs. Besides the germs of these diseases bad water may contain several worms or their eggs, which produce in man various morbid symptoms. A bacteriological examination gives important indications of the purity or otherwise of a water and of its fitness for drinking purposes. Thresh has estimated that a bacteriological examination is a thousand times more delicate than a chemical analysis.

Most waters in nature contain germs in greater or lesser numbers. A few deep wells and mountain springs yield practically germ-free water, but excepting these, few natural waters are devoid of germs. These may be derived from air as in rain water or from the upper layers of the earth, through which the water flows. Various factors increase the bacterial contents of surface waters—these are sewage contamination, and rain water flowing over agricultural land ; while the following influences tend to kill off bacteria in water, viz., sedimentation, sunlight, lack of food-supply, temperature, and struggle for existence. The bacteria present in waters may be divided into :—

1. *The water bacteria.*—These bacteria are naturally present in all waters, however pure the water may be ; their presence is not of any significance.

2. *The soil bacteria.*—These are often added to water from soil washings.

3. *The sewage bacteria.*—Surface water is usually polluted with sewage or the excreta of men and animals.

It is to the detection and isolation of these special bacteria that the labours of the water analyst are mainly devoted. Their presence indicates that the water has actually received some sewage pollution and that at any time disease-producing organisms may gain access to it with the sewage. The object of a bacteriological analysis of water may therefore be said to be to ascertain the presence or otherwise in water of organisms derived from sewage. There are, roughly speaking, two classes of

organisms in sewage: (1) pathogenic organisms like typhoid, (2) the bacteria normally present in stools like *B. coli.* Under certain conditions the latter may become pathogenic, but generally they are not so. If methods could be devised by which these disease-producing organisms could be easily detected in water, water analysis would be a simple and straightforward business. Unfortunately the methods at present available for the isolation of these pathogenes are both difficult and uncertain. Further, a water that is occasionally polluted with sewage may not show these pathogenic germs at the time of analysis, as the latter may not always be present even in sewage, or they may have disappeared from the sample. Consequently, if search is made only for these organisms a dangerous water that may at any moment infect a whole community may be passed as fit for consumption, on the ground that at the time of analysis no pathogenic organisms were found. For these two reasons these organisms are not generally sought for in routine water analysis. The analyst is mainly occupied with the detection and enumeration of the sewage bacteria. This brings us to a consideration of the bacteriology of sewage. Sewage is a highly complex fluid, and bacteria of various kinds may be present in it. It would be difficult nor would it serve any useful purpose to separate and identify each and every one of the many thousands of organisms that are present in sewage. After several years' laborious work it has been ascertained with a fair amount of certainty that in sewage a particular class of organisms called *B. coli* predominates over others, and that it is not present in places which have not been subject to sewage contamination. The typical *B. coli* may be defined as a short, non-sporing, slightly motile gram negative bacillus, fermenting glucose and lactose with acid and gas formation and producing indol.

Collection of water samples.—Samples of water for bacteriological analysis should be collected in sterilised bottles of about six ounces capacity. The analysis should be started within two or three hours of collection. As soon as water is stored in a bottle its conditions of equili-

brium are upset and a change in the bacterial contents begins. Some bacteria multiply enormously while others disappear, so that an entirely false picture of the flora of the water is obtained. If an immediate analysis is not possible the bottle should be preserved in ice until the time of analysis. In collecting samples attention should also be paid to a few minor details :—

1. If it is taken from a tap the water should be allowed to flow on for about five minutes before the sample is collected

2. If from a tank or river the sample should be taken at a little distance away from the banks. A piece of string is attached to the neck of the bottle and sterilised, and only this sterilised string should be allowed to touch the water.

3. If from a well the water may be obtained by lowering a sterile bottle weighted with lead into the well with a sterilised cord.

The methods of analysis may now be detailed :—

Total count.—The total number of organisms of all kinds present in the water may be estimated. A tube containing about 10 c.c. of Agar medium is melted and cooled to about 40°C., mixed with about 1 c.c. or 0.1 c.c. of the water to be analysed, the whole well mixed and placed in a sterile petri dish and incubated at 37°C. for three or four days. After this period of incubation the total number of colonies visible to the naked eye may be counted. This gives a rough estimate of the number of organisms of all kinds present in the water. It must at once be stated that even in this medium all the organisms present in the water do not grow, such as the anaerobic organisms, the nitrifying and other similar organisms, and the natural water bacteria. While the temperature of incubation is particularly favourable to the growth of most sewage organisms, it is not so for some derived from other sources. Still, however, this is not a serious drawback to this method, as in water analysis the analyst is particularly interested in the organisms that may be derived from sewage. The number of bacteria present depends roughly on their amount or the extent to which

the water has been contaminated with sewage or decomposing organic matter. This method of estimating the total number of organisms in water is particularly useful in determining the efficiency of filtration processes. A good filter should remove a very large percentage of the organisms present in the water to be filtered, and the filtered water should not contain more than one hundred organisms per cubic centimetre. By this simple method it can be ascertained whether a filter is working efficiently or not. Mention has already been made that this method is not an ideal one for determining the quality of a water, since it tells nothing of the nature of the organisms or of the source from which they may be derived. In addition to this method the number of *B. coli* present in the water should therefore be estimated. As already noticed *B. coli* is used as an index of sewage pollution.

Enumeration of B. coli.—The number of *B. coli* present in the water is estimated by adding varying quantities of the water to tubes containing bile salt, lactose, peptone, and broth; and incubating at 42°C. or 37°C. In this medium the soil and water bacteria do not grow at the temperature of incubation, while the *B. coli* grows luxuriantly, fermenting the sugar and producing acid and gas. An indicator litmus alkali— is also used in the medium to show the presence of acid. The least quantity of water which produces acid and gas in this medium is noted and *B. coli* is said to be present in that amount. The above-mentioned change in this medium is only used as presumptive evidence of the presence of *B. coli*. While the large number of bacteria giving the above reaction in this medium are undoubted *B. coli* derived from sewage, there still remain a small minority which, though giving the above reaction, are not typical *B. coli* nor are they derived from sewage. Some analysts therefore isolate the bacilli that give a positive reaction in the glucose medium and ascertain later whether they possess all the characters of *B. coli* or not.

Search for streptococci.—Streptococci are abundantly present in fresh fæces and sewage, and therefore it has been suggested that they may be used as indicators of

sewage pollution like *B. coli.* Concerning the precise significance of their presence in water there are still differences of opinion, but the bulk of evidence is that they are present only in highly polluted waters.

Search for B. enteritidis sporogenes.—This is an anaerobic spore-bearing bacillus and is abundantly present in sewage and excreta. It is therefore often used as an indicator of fæcal pollution. To search for this bacillus large quantities of water must be used. The water is added to about an equal quantity of milk and boiled at 80° C. for about ten minutes, and incubated anaerobically at 37° C. for forty-eight hours. At the end of this period a characteristic change is produced when the *B. enteritidis sporogenes* is present attended with abundant gas formation and coagulation of casein. When this change is produced it may be assumed that *B. enteritidis sporogenes* is probably present. Of late the value of this test has been questioned. Some authorities maintain that the organism is highly resistant and that it can remain alive even under adverse conditions for long periods. If this be so the presence of the organism in the water does not furnish any valuable information about its quality, as it indicates only a pollution which may have gained access to the water at some remote past.

Interpretation of results.—The extreme delicacy of this method renders the interpretation of the results of a bacteriological analysis a task of considerable difficulty. The fullest possible information should be had about the water, and the surroundings from which it has come, noting particularly recent rainfall, if any. The object of the analysis may be :—

1. To ascertain if any disease-producing organisms are present.
2. To ascertain if a filter is working satisfactorily.
3. To ascertain if pollution by sewage exists.

As regards the first the presence of pathogenic organisms absolutely condemns water for drinking purposes.

As regards the second a good filtered water should show no *B. coli* in about 100 c.c. and a total count less than 100 per c.c.

As regards the third it is difficult to lay down any arbitrary standards. Good deep well and spring water should show no *B. coli* in about 50 c.c. and a total count less than 100. Surface waters are poorest in quality during the rains, when they receive the washings of an indifferently preserved catchment area possibly including the excreta of men and animals. The *B. coli* may be present in 0.01 c.c. or about 100 to the cubic centimetre, and the total count may be several thousands per c.c. Gradually the various factors that make for self-purification in natural waters come into play, and a progressive improvement in the quality of the water is manifested on storage. In India sunlight and sedimentation might be said to be the most important of these. A well-sunned surface water should contain *B. coli* only in about 5 c.c. and a total count less than one thousand.

THE CALCUTTA MUNICIPAL ACT, 1899.

General duties of the municipal authorities in respect of the supply of water.

Sec. 237.—The Corporation shall provide a supply of filtered water within all parts of Calcutta, and supply of unfiltered water within such parts of Calcutta as they may think fit, and shall cause such separate mains, pipes and taps to be laid and placed as may be necessary.

Sec. 238.—(1) The Corporation shall erect sufficient and convenient public stand-posts for the gratuitous supply of filtered water for domestic purposes.

Sec. 239.—(1) The Corporation shall erect sufficient and convenient platforms for the gratuitous supply of water for bathing purposes.

(2) All such bathing platforms shall, as far as may be practicable, be supplied with filtered water.

Sec. 243.—It shall be the duty of the Chairman to test the purity of the supply of filtered water once every week and to lay the result before the general committee.

Sec. 244.—Subject to certain provisions (section 254) filtered water shall be supplied for domestic purposes only.

Sec. 245.—No person shall, without the written permission of the Chairman, use for other than domestic purposes filtered water supplied under this chapter for the said purposes.

Sec. 246.—(1) Unfiltered water shall be used for public purposes, such as,—(*a*) Street washing ; (*b*) flushing of municipal drains, public privies and urinals, gully pits and hackney-carriage stands ; (*c*) extinguishing fires ; (*d*) flushing privies and urinals on private premises connected with the sewers ; (*e*) for flushing drains, cleansing stables, cattle-sheds and cow-houses occupied by animals which are not kept for profit or hire.

(2) It shall not be used for domestic purposes.

Prohibition of Waste and Pollution of Water

Sec. 268.—(1) No occupier of any premises shall negligently or otherwise suffer such water to be wasted, or shall suffer the pipes, taps, works and fittings for the supply of water, or any of them to remain out of repair to such an extent as to cause a waste of water

Sec. 284.—Whenever a supply of filtered and unfiltered water has been provided in any street, the Chairman may, by written notice, require the owner of any well, situated in premises which are supplied from the mains, to fill it up with suitable materials.

Sec. 459.—The Chairman may from time to time set apart suitable places for use of the public for bathing, washing animals, or for drying clothes, and may prohibit the use by the public for any of the said purposes of any place not vesting on the Corporation.

Sec. 461.—No person shall (*a*) bathe in or near any tank, reservoir, fountain, cistern, duct, stand-post, stream, well or other sources of water-supply or in any place vesting on the Corporation ; (*b*) wash or cause to be washed, in or near any such source or place, any animal, clothing, or other article ; (*c*) throw, put or cause to enter into the water in any such source or place any animal or other thing ; (*d*) cause or suffer to drain into or upon any such source or place or to be brought thereinto or thereupon, anything whereby the water may be in any degree fouled or corrupted ; or (*e*) dry clothes in or upon any such place.

Sec. 462.—No person shall (*a*) steep in any tank, reservoir, stream, well or ditch, any animal or any vegetable or mineral matter which is likely to render the water thereof offensive or dangerous to health ; or (*b*) while suffering from any contagious or loathsome disease, bathe on, in or near any bathing platform, tank, reservoir, fountain, cistern, duct, standpost, stream, or well.

CHAPTER II

AIR

PURE air is necessary for healthy life, and perfect health can only be maintained when, in addition to other requirements, there is an abundant supply of pure air. Health and disease are in direct proportion to the purity or otherwise of the air; increase in the amount of ill-health being largely due to impurities of the air.

COMPOSITION OF AIR

Air is a mixture and not a chemical compound, and its composition is practically constant. This uniformity of composition is due to diffusion, constant movement by means of air currents and the reciprocal action of animals and plants on air.

The following is the approximate composition of air:

Oxygen	209.6 per 1000 volumes
Nitrogen	790.0 ,,
Carbonic acid	0.4 ,,
Watery vapour	varies with temperature
Ammonia	trace
Organic matter	variable
Ozone	variable
Salts of sodium	variable
Other mineral substances ..	variable

Nitrogen forms 79 per cent. by volume and 76.9 per cent. by weight. Another important body forming about 1 per cent. of the nitrogen of the air is *Argon*, having an atomic weight of 39.8. Oxygen is the principal agent in supporting animal life and promoting the combustion of bodies.

The presence of nitrogen is as a diluent and to modify the activity of the oxygen.

Ozone.—In popular language this is known as "condensed oxygen," $3O_2=2O_3$. It is found in very minute quantities, if at all, in the atmosphere of towns. Its chief source in nature is atmospheric electricity, and it is also partly derived from evaporation of large masses of water. Hence ozonised air is abundant on the sea-coast. The readiness with which it parts with its extra atom of oxygen makes it of special value from a hygienic point of view, for by this action it renders organic effluvia innocuous. It is recognised by its peculiar odour, and by its turning blue a piece of blotting paper moistened with a solution of potassium iodide and starch. It is non-combustible and slightly soluble in water.

Carbon Dioxide.—The chief sources of carbonic acid in the air are respiration, fuel combustion, decomposing animal or vegetable matter, volcanic and other allied phenomena. Along with its production there are means of its removal from the atmosphere. The quantity of free CO_2 is subject to slight fluctuations ; The proportion of CO_2 is increased by oxidation of organic matter, respiration, putrefaction and chemical action in the soil, and is decreased by vegetation, by currents of winds and rain, and in rooms by proper ventilation · CO_2 is said to be absent from desert air. The inhabited rooms contain between 3 to 4 parts per 10,000 and when this is exceeded it should be considered as impurity. The amount of CO_2 varies from 0.02 to 0.05 per cent. Being a direct result of combustion, CO_2 is found in considerable amount in big cities and towns.

Ammonia.—Ammonia and its salts are always present in the air in small quantity. The amount of ammonia present in the air is an indication of decomposition of animal matter taking place on the surface. Its amount diminishes after rain, which dissolves it.

Organic and Suspended Matters.—These consist of minute particles of mineral matters, common salt (especially near the sea), soot and dust, bacteria and their spores, vegetable debris, etc.

Moisture.—This is always present in the air, but is subject to great variations ; the amount however depends on temperature. There is more watery vapour in the tropical atmosphere than in temperate and cold climates, more at sea than on land, more in summer than in winter, and at midday than in the morning and evening. Water has an important influence on health both directly and indirectly. The evaporation of the moisture from the skin is the great regulator of the temperature of the body, and if the quantity of watery vapour in the atmosphere is great, this is interfered with.

Physical Properties.—100 cubic inches of air weigh about 32.5 gms. at 32°F. The volume of gas under varying conditions of pressure is inversely proportionate to the pressure (Boyle's Law), and when heated it increases in volume according to a special law (Charles' Law). Gases diffuse at a rate inversely proportional to the square root of their densities.

Impurities of Air

The chief sources of impurity of the air are the following :—

1. Products of respiration.
2. Products of combustion.
3. Products of decomposition.
4. Dust.
5. Bacteria.

1. *Products of Respiration.*—The commonest and at the same time the most important impurities in the air of occupied rooms are those associated with respiration. CO_2 is being constantly formed in the body and is carried to the lungs by the venous blood. The changes brought about in the air by respiration and emanations from the skin are largely responsible for ill-health. Oxygen is considerably reduced and CO_2 is increased and there is also a trifling change in the proportion of nitrogen.

Foul odours, increased moisture and raised temperature help considerably to the discomfort of the air from

which oxygen has been reduced, which is vitiated by an excess of CO_2 and by added volatile organic matter and dust of various kinds. It is this combination which is most favourable to the growth and development of organisms, disease producing or otherwise.

A man usually respires about 17 times in a minute and at each respiration an adult gives out 30·5 cubic in. (500 c.c.) of air. An adult male gives off 0·72 c. ft. in an hour. But actual experiments show an average of 0·9 c. ft. of CO_2 during gentle exercise. In a mixed community 0.6 cubic ft. of CO_2 per hour per head may be taken as the standard. The proportion of gases in inspired and expired air per 100 parts are as follows :—

	Inspired air	Expired air
Oxygen ..	.. 20.96	16.40
Nitrogen ..	.. 79.00	79.19
Carbonic acid	.. 0.04	4.41

Thus it will be seen that the expired air contains 4 to 5 per cent. less of oxygen and 4 per cent. more of CO_2. The temperature of the expired air is higher than that of the inspired air. These may also be derived from volatile products given off from the teeth and gums, from dirty skins, and from excretions adhering to foul clothing.

(*a*) *Carbonic Acid.*—The amount of CO_2 in the air has been adopted as an index of the total condition which is prejudicial to health and comfort. As long as CO_2 does not exceed 2 to 3 p.c. hardly any effects are felt. But the breathing becomes quicker and deeper with the increase in percentage till it reaches 5 p.c. when there is distinct panting. The dyspnœa becomes distressing when it reaches 7 or 8 p.c. The average air contains 0.03 to 0.04 CO_2 per 100, or 0.3 to 0.4 per 1000 volumes, and if a man breathes for an hour in a room of 1000 cubic ft., the amount of CO_2 at the end of the hour, if no air is admitted or withdrawn meanwhile, will be $0.6+0.4=1.0$ cubic ft. An average man gives off about half a cubic foot of CO_2 per hour. But this amount of CO_2 is unwholesome, and must be diluted till the total

CO_2 comes down to 0.6 per 1000. This is done by allowing 2000 cubic ft. of normal air per hour, thus making up a total of $2000+1000=3000$ cubic ft. of air per hour.

(*b*) *Watery Vapour.*—The amount of water given off by the lungs and skin in twenty-four hours by each person varies with the temperature and humidity of the surrounding atmosphere, as well as with the amount of work done. 10 ozs. of water from the lungs, and 20 to 30 ozs. from the skin may be regarded as the average amount under average condition. The tendency of the air is to reach saturation, and this makes the air of a crowded room so uncomfortable.

(*c*) *Organic Matters.*—As given off by the lungs and skin the organic matters differ much in health and disease. They consist of vapours from the lungs and mouth, volatile and fatty acids from the skin and particles of epithelium. It gives an appreciable quantity of albuminoid ammonia when distilled with alkaline permanganate. The organic matters promote the growth of microbes, and milk, meat and other foods when in contact with them rapidly become tainted.

2. *Products of Combustion.*—The chief products of combustion are carbon dioxide and carbon monoxide, sulphur compound, or watery vapour. When fuel is burnt the carbon of wood, coal, or charcoal unites with the oxygen of the atmosphere and forms either carbonic acid or carbon monoxide. The former is a comparatively harmless compound and the latter is a narcotic poison.

3. *Products of Decomposition.*—Decomposing animal and vegetable matters give off poisonous gases. Sulphuretted hydrogen is evolved from marshes, and from collections of refuse and decaying vegetable matter. When present even in the proportion of 1 in 7000 it is dangerous to human life. When present in very minute quantities giddiness, headache, and general depression are produced.

4. *Dust and Suspended Matters.*—Both organic and in organic substances are suspended in the atmosphere.

Scales of epithelium, fibres of cotton, linen and wool, particles of hair, etc., can be found in inhabited but imperfectly ventilated rooms. A peculiar smell hangs about sick rooms or hospitals, chiefly due to the patients' excretions. Dust arising from filing metals, stones or pearls, spinning textile fibres of all kinds, cement, etc., add to the suspended impurities of air.

5. *Micro-organisms.*—The great source of aerial bacteria is the soil which is teeming with micro-organisms. On windy days in dry weather the air always contains more bacteria than at other times. Bacterial population of air is also derived from all collections of dust and dirt from rooms and from inhabited spaces of any kind. Although the microbes present in the air are considerable in number, for the most part they are harmless, but specific disease germs of tubercle, typhoid, etc., have also been isolated from the air of crowded rooms. Sunlight, especially in the tropics, has a germicidal power and is an important factor in reducing the number of air organisms. The bacteria found in the atmosphere are carried in the form of particles of dust. The pathogenic non-sporing organisms, which cannot live in the dry state, can thrive on dust particles sufficiently large to prevent complete drying.

A number of manufacturing impurities also pollute the air. The chief ones are :—

(*a*) Hydrochloric acid gas from alkali works.

(*b*) Sulphur dioxide and sulphuric acid from copper melting and bleaching works.

(*c*) Hydrogen sulphide from chemical works.

(*d*) Carbon monoxide, carbon dioxide, and sulphuretted hydrogen from brick-fields and cement works.

(*e*) Carbon monoxide from iron and copper melting works.

(*f*) Organic matters from glue and gelatin factories.

(*g*) Zinc fumes from brass works.

(*h*) Arsenical fumes from metal works, where arsenic is used as an alloy.

(*i*) Phosphorus fumes from match factories.

(*j*) Carbon disulphide fumes from india-rubber works.

Air in Mines.—This is rich in carbonic acid (2 parts per 1000), and contains in addition carbon monoxide, hydrogen and sulphuretted hydrogen. The deficiency of oxygen in air (200 parts per 1000 of air) is the cause of death in mines, following explosions. The gases that are formed in a mine after an explosion are called "after damp," whereas "black damp or choke damp" is formed ordinarily, and is the residual gas left on slow oxidation of the carbon and hydrogen of coal by air. It does not explode when mixed with air, and it does not support combustion or life owing to the deficiency of oxygen.

Sewer Air.—The air of sewers has long been regarded as dangerous and a likely source of infection in certain diseases, but it is only of late that much attention has been directed to its careful examination. The gaseous products of the decomposition of animal organic matter have been sought for, as also the micro-organisms of infectious diseases, *e.g.* the bacillus of typhoid fever. It is now believed that the air of sewers plays very little part in the conveyance of typhoid fever: and that the air of sewers, as regards organic matter, carbonic acid, and micro-organisms is in a very much better condition than the air of naturally ventilated school rooms.

Impurities due to Combustion

Coal contributes largely to the impurities of the atmospheric air. There are three kinds of coal—anthracite or smokeless coal, bituminous coal and lignite. Bituminous coal is used for the manufacture of illuminating gases and for domestic purposes. It gives off during combustion three times its weight of carbonic acid gas, small quantities of carbonic oxide, sulphurous and sulphuric acids, carbon disulphide, sulphuretted hydrogen, and moisture. About 1 per cent. is given off in the air as soot and tarry products. One pound of coal requires about 240 to 320 cubic ft. of air for complete combustion. The impurities imparted to air during combustion of coke and wood are similar to those of coal with the exception that wood only gives carbon dioxide and monoxide

with more water but less sulphur compounds. When these products of combustion pass into the air they are at once diluted and purified by the currents of air and by the diffusion of gases.

By " one candle power " is meant the light given out by a sperm candle burning 120 grs. per hour. This gives out 0.4 cubic ft. of carbonic acid and consumes about 1000 cubic ft. of fresh air hourly. The chief popular illuminant is coal gas. An ordinary gas burner consumes about 4 cubic ft. of gas. and gives off about 2 cubic ft. of CO_2, per hour. Hence about 10,000 cubic ft. of fresh air per hour for each burner burned is necessary if the CO_2 is to be kept down to 0.6 per 1000. When purified, coal gas contains approximately hydrogen 47 per cent., marsh gas 37 per cent., carbonic oxide 6 per cent., illuminants (acetylene, ethylene) 6 per cent., carbonic acid 1 per cent., nitrogen, sulphurous acid, etc., 5 per cent. The products of combusion of coal gas are nitrogen 67 per cent., water 16 per cent., carbonic acid 1 per cent., carbonic oxide variable, sulphurous acid and ammonia. When burnt, 1 cubic ft. of ordinary coal gas gives off half its own volume of CO_2 and 1.34 cubic ft. of watery vapour ; therefore, the degree of pollution of air can be easily estimated knowing that on an average 4 cubic ft. of gas per hour are consumed.

Coal gas unconsumed is poisonous ; minute escapes are very dangerous. Of the ingredients of coal gas all except hydrogen, nitrogen, and the hydrocarbon vapours are in various degrees poisonous. When burnt, coal gas yields also CO_2 and SO_2, consequently coal gas, burnt or unburnt, is always an impurity in the air of a room. Some forms of coal gas contain large amounts of carbon monoxide and are especially dangerous.

The incandescent electric lamp is the best source of light from a sanitary point of view, as it is not dependent on the oxygen of the air and does not vitiate the atmosphere in any way. The next best is the Welsbach incandescent gas burner ; it is an ordinary Bunsen burner, over the flame of which a cap (mantle) of asbestos gauze net work is suspended. This is rendered non-inflammable

by chemical treatment. The flame itself is intensely hot, though not luminous, and light is produced by the mantle being rendered incandescent and so giving a brilliant illumination—whiter and steadier than the ordinary gas flame. This burner gives off less CO_2 than any average oil lamp, and consumes less than half the amount of gas which an ordinary burner does. It evolves half as much heat, but produces three times more illuminating power than the best ordinary gas burner.

Diseases due to Impuritifs of Air

A. **Effects of Dust and other Solid Impurities.**—Dust consists principally of mineral particles of formed or unformed organic matter of animal or vegetable origin, *e.g.* epithelia, fibres of wool or cotton, or particles of animal or vegetable tissues. The effects depend on the amount inhaled and on the physical condition of the particles, whether sharp-pointed or rough, etc. They always injure health and the principal affections arising therefrom are catarrh, bronchitis, fibroid pneumonia, asthma, and emphysema. Potters' asthma (emphysema) is due to dust, and miners' anthracosis to coal dust.

B. **Effects of Suspended Impurities.**—Workers in rags and wool suffer similarly from dust. Dust from fleeces of wool has caused anthrax. Mill-stone cutters, stone masons, pearl cutters, sandpaper makers, knife grinders, millers, hair dressers, miners, fur-dyers, weavers, etc., all suffer from diseases of the lungs caused by the inhalation of dust and other suspended matters. Cigar-makers inhale the dust of tobacco leaves and may suffer from tobacco poisoning. Inhalation of pollen grains produces hay asthma. Brass founders inhale fumes of oxide of zinc, and suffer from diarrhœa, cramp, etc. Match-makers inhale fumes of phosphorus and suffer from necrosis of the lower jaw. Ulceration and finally destruction of the mucous membrane of the nose occurs in those engaged in the manufacture of bichromate of potash. Workers engaged in the preparation of glass-mirrors often suffer from mercurial posioning, while

plumbers may be attacked with colic and palsy. Workers in arsenic, as those who prepare wall papers and artificial flowers, suffer from symptoms of arsenic poisoning.

C. **Effects of Gases and Volatile Effluvia** :—

(*a*) *The effects of gases* on health are disputed. The chief impurities are :—

1. Hydrochloric acid vapours which cause irritation of the lungs and diseases of the eye.

2. Carbon disulphide vapours causing headache, muscular pain and depression of the nervous system.

3. Ammonia causing irritation of the conjunctiva.

4. Carburetted hydrogen causes headache, vomiting, convulsions, etc., when inhaled in large quantities.

5. Carbon monoxide imparts a cherry red colour to the blood, and, by interfering with oxygenation, may cause death.

6. Hydrogen sulphide causes diarrhœa, headache, nausea, and muscular and nervous depression.

(*b*) *Effects of effluvia* :—

1. *Effluvia from Brick-fields.*—Bricks are burnt in two ways, in clamps and in kilns. *Clamp burning* is very offensive, for besides the ordinary products of combustion, certain pyroligneous matters are also formed, which have a very disagreeable smell and are injurious to heatlh. Clamp burning should not, therefore, be permitted near inhabited localities. In clamps bricks are arranged in quadrangular piles alternating with combustible materials, and burning is carried out by means of coal fires and chips. Sometimes dust-bin refuse is used to burn the bricks ; in such cases the partially burnt organic vapours are highly disagreeable. In *kiln burning* bricks are burnt with the aid of coal only, and if the kilns are provided with flues the liability to nuisance is much less, as the products of combustion are more perfectly consumed.

2. *Effluvia from Offensive Trades.*—The effluvia arising from stables, cowsheds, tanneries, fat and tallow factories, gut scraping, bone boiling, paper making etc., are all very offensive, and affect health by causing headache, diarrhœa, etc. (*See* Offensive Trade.)

3. *Effects of Gas from Sewers and House Drains.*—The air in the main sewer is purer than that of the house drains. Among the effects may be mentioned diarrhœa, gastro-intestinal affections, sore-throat, diphtheria, anæmia, and constant ill-health. Diseases like cholera, enteric fever, erysipelas, measles, scarlet fever, etc., are aggravated by sewer gas. Children are affected more than adults. A severe form of tonsillitis is often found in the occupants of a badly drained house. This is commonly known as "sewer air throat." Persons working in well-ventilated sewers do not usually suffer from any illness, but if ventilation is wanting syncope may occur.

4. *Effluvia from Decomposing Organic Matter.*—Gases from decomposing carcases may cause diarrhœa and dysentery. Gases from manure and similar manufactories cause nervous depression, gastro-intestinal irritation, and occasionally ophthalmia.

D. **Effects of Air Vitiated by Respiration.**—When carbonic acid in a room exceeds 0.6 volumes per 1000, the atmosphere becomes perceptibly close and stuffy to a person entering from outside. This sense of discomfort is due to the excess of CO_2, deficiency of oxygen, and to increased heat and moisture. The effect of expired air has a deteriorating influence on health, as it produces heaviness, headache, and nausea.

Air vitiated by respiration differs in various directions from ordinary air; in closed and confined rooms the exhaled air is breathed and rebreathed over and over again, each time becoming more and more foul and impure. In minor and ordinary degrees the earlier symptoms are dullness and lassitude, headache and loss of appetite, pallor and anæmia, eventually proving highly injurious to health. Lungs are most frequently affected, and consumption and scrofula are often associated with this condition. This is more marked when combined with deficient exercise and poor feeding. The increased facility for transmission of diseases like measles, diphtheria, etc., is due to the ready growth of disease producing organisms in such air, and to the predisposition brought about by the lowered constitution.

Examination of Air

Collection of the Sample.—For examination purposes, air is best collected in large wide-mouthed glass jars of about 3 to 4 litres capacity, thoroughly cleaned and dried. The sample should be taken at the time when the atmosphere is at its highest degree of vitiation, as for example, in the case of school rooms when all the students have been in the class for some time. There are two methods of taking the sample :—

1. Take the jar filled with distilled water into the room, and empty it by turning it upside down. Dry it in the room and put the stopper in lightly or cover it up with an india-rubber cap, so that no outside air can get an entrance.

2. Air may be blown in by bellows having a long nozzle, so that it may reach the bottom of the jar, and displace air from the very bottom.

The vessels should always bear a label on which the cubical capacity of the jar, the barometric pressure, and the temperature at the time of the collection of the sample should be noted.

1. **Examination by the Senses.**—One with an acute sense of smell can readily detect the presence of carbon disulphide, sulphuretted hydrogen, coal gas, organic matter, etc. De Chaumont was the first to point out that the peculiar fœtid smell perceived on entering an inhabited room from the outside was the result of the influence of atmospheric humidity on the organic matter. The impression on coming from the open air into an inhabited room should be recorded at once, as the sense of smell gets dulled very soon. The smell also depends on the cleanliness or otherwise of the room and its occupants.

2. **Chemical Examination.**—The ill effects are due more to the presence of CO_2 and organic matter than to the deficiency of oxygen. Hence the determination of CO_2 in air is of great value ; being the product of combustion and respiration it gives an index of the degree of pollution of the air. The popular method of estimating

the amount of CO_2 is that of Pettenkofer, and depends on the fact that an alkaline medium like water or baryta water absorbs CO_2, the alkalinity being thus diminished. Therefore the difference in the degree of alkalinity before and after the experiment gives an index of the amount of CO_2.

Technique.—Add 50 c.c. of clear and fresh baryta water to the sample of air in Winchester quart and replace the stopper. Allow it to stand for some time with occasional shaking to allow the CO_2 to mix with the baryta water to form barium carbonate. The alkalinity of baryta is determined by a standard solution of oxalic acid, 1 c.c. of which is equivalent to 0.5 c.c. of CO_2. Phenolphthalein is used as an indicator, the colour disappearing on neutralisation. The following is an illustration :

The jar is found to contain 3950 c.c.

As 50 c.c. baryta water were run into the jar, the air experimented on $= 3950 - 50 = 3900$ c.c.

On titrating 25 c.c. of the original baryta water, 22.50 c.c. standard acid solution were required to neutralise it.

The baryta water in the jar required 19.35 c.c.

$22.50 - 19.35 = 3.15$ c.c. = difference of acid used. But 1 c.c. of acid = 0.5 c.c. CO_2 at 0°C. and 760 mm. of mercury.

Therefore CO_2 taken up by 25 c.c. of bartya $= \frac{3.15}{2} =$ 1.575 c.c.

As 50 c.c. were used the CO_2 absorbed by the baryta $= 3.15$ c.c.

This was present in 3900 c.c. of air. Therefore the CO_2 $= 0.80$ per cent.

Correction may be required for variations from the normal pressure of 760 mm. and normal temperature of 0°C., in accordance with ordinary rules which are given here :—

Measurement of quantity of gases at the normal temperature of 0°C. and pressure, i.e. 760 mm. of mercury.

The variations which are produced in the volumes of gases by changes of pressure and of temperature, within

moderate limits, are in accordance with the following laws :—

✓ (*Boyle's Law.*—When the temperature of a quantity of gas is kept constant, the volume which the gas occupies varies *inversely* as the pressure). Thus, supposing the temperature to be constant throughout, a quantity of gas which occupies 1 litre at a given pressure occupies half a litre when the pressure is doubled ; one-third of a litre when the pressure is trebled, 2 litres when the pressure is diminished to one-half the original pressure, 3 litres when it is diminished to one-third, and so on.

A numerical illustration will show the mode of applying this rule in measuring the quantity of gases.

We measure 2000 c.c. of a gas at atmospheric pressure, and the barometer reads 742 mm. The question is : What would be the volume of this amount of gas at 760 mm. barometric pressure ? It will be $2000 \times \frac{742}{760}$ c.c. It is not necessary to use any formula, but absolutely essential to ask : Is the new pressure greater or less than the old ? Here it is *greater*. Hence, according to the law, the new volume will be *less*, so that the fraction must be arranged in the smaller number in the numerator.

(*Charles' Law.*—When the pressure, to which a quantity of gas is subjected, is kept constant, the volume which the gas occupies varies *directly* as the absolute temperature). The absolute temperature is obtained by adding 273 to the observed temperature, in degrees centigrade, of the gas.

The application of this law may be best illustrated by an example. We obtain 2000 c.c. of a gas at 20°C. and wish to know what volume it would occupy at 0°C. To answer the question we convert the centigrade temperatures to the absolute scale by adding 273 to each. Thus $2000 \times \frac{273+0}{273+20}$ or $2000 \times \frac{273}{293}$ = volume at 0° required. No formula is needed. We simply ask whether the new temperature is higher or lower than the old one. Here it is *lower*. The new volume will therefore be *smaller*

than the old one. So we take care to place the smaller number in the numerator.

The behaviour of gases in respect to changes of temperature and pressure is perfectly independent of one another, so that the above laws may be applied to any example, either in succession, using the answer for the first calculation in making the second, or simultaneously. Thus 2000 c.c. of gas of 742 mm. pressure and 20°C. become $2000 \times \frac{742}{760} \times \frac{273}{293} = 183.8$ c.c. at 0°C. and 760 mm.

The normal temperature and pressure are usually written as N.T.P.

The above laws are usually put in the mathematical form thus :—

$$\frac{V\ P}{V^1 P^1} = \frac{273+t}{273+t'}$$

One should familiarise himself with the method of calculating the changes of volume suffered by gases, by changes of temperature and pressure, by working out a number of examples such as the following :—

1. If 30 litres of gas are cooled from 25°C. to 0°C. what is the diminution in volume, the pressure being constant ?

Ans.—2.51 litres.

2. A quantity of gas measures 2500 c.c. at the temperature 27°C. Required its volume when the temperature is lowered to 0.°C.

Ans.—2275 c.c.

3. Reduce 2280 c.c. of air at 30°C. and 750 mm. to 0°C. and 760 mm.

Ans.—2027.4 c.c.

In a particular estimation of CO_2 in air, the capacity of the Winchester quart was 1950 c.c. ; 50 c.c. of baryta water used and 25 c.c. of this = 12.9 c.c. of standard oxalic acid (1 c.c. = 0.5 c.c. of CO_2 at N.T.P.)

25 c.c. of the original baryta water = 14.2 c.c. of oxalic acid. The temperature and pressure at the time of the experiment being 29°C. and 750 mm.

Calculate the volume of CO_2 in 10,000 vols. of air at the normal temperature and pressure.

Ans.—7.61.

Organic impurities may be estimated by aspirating a definite amount of air through a freshly prepared dilute solution of potassium permanganate of known strength. The result is determined by calculating the number of cubic feet of air required to decolorise 0.001 grm. of potassium permanganate in solution.

3. **Microscopical Examination of Air.**—Aspirate air slowly through a series of bottles each holding about 100 c.c. of distilled water, and allow the suspended matter to settle, drain off the supernatant fluid and examine the residue under the microscope.

4. **Bacteriological Examination of Air.**—Various methods have been suggested for the estimation of the number of micro-organisms in the air, of which Hesse's method is generally adopted. The apparatus consists of a glass cylinder about 30 in. long and 2 in. in diameter, one end of which is plugged with a rubber cork through which a glass tube passes, the other end is covered with a piece of sheet rubber perforated with a hole $\frac{1}{4}$ to $\frac{1}{2}$ in. in diameter, over which is placed another unperforated sheet of rubber. The small tube is plugged with cotton-wool. Inside the cylinder, which has been previously sterilised, 40 to 50 c.c. of liquid gelatin is allowed to solidify, over which the germs are deposited during the passage of the air. The ends of the tube are then plugged with sterile cotton-wool and it is placed in the incubator for twenty-four hours or more, after which the colonies are counted when they have developed.

CHAPTER III

VENTILATION

THE term "ventilation" has a very wide significance, but it is generally restricted to the means of removal or dilution of the foul gases and impure suspended matters which have accumulated in the atmosphere of buildings inhabited by men and animals. This is sometimes called *internal ventilation.* But in the case of the general air space of towns advantage is taken of the natural means of purification of air. This is done by making the streets broad, building houses moderately high, and not very close to one another, so as not to impede free circulation of air. This *external ventilation* is of primary importance, for upon the purity or otherwise of outside air depends the possibility of good internal ventilation. Efficient external ventilation may also be ensured by preventing other impurities from entering the air, by watering the streets to lay the dust, by careful inspection of all drains and sewers, by transporting all offensive trades and occupations to special quarters, by the speedy removal of street and other refuse, and by keeping plenty of open spaces and parks.

Ventilation to be satisfactory must conform to certain conditions, viz, it must supply pure air from without, it must keep the air within the room at a proper temperature and maintain a continuous circulation. It must also be able to remove gases, odours, bacteria, dust, etc., which contaminate the air, and dilute and remove the impurities produced by combustion.

AMOUNT OF AIR REQUIRED FOR VENTILATION

This depends upon the amount of impurities present in the air requiring dilution and dispersion. Ventilation

aids only in the removal of the products of respiration and combustion. Whatever may be the impurities, carbon dioxide is regarded as the chief index of air vitiation.

1. **Amount of Air required for the Healthy.**—The question naturally arises what should be the standard of purity of air in a dwelling house? A room should ventilate itself thoroughly when all the doors and windows are closed, so that a person coming in from the fresh air should not perceive any smell or stuffiness. It has been found by experience that when the amount of CO_2 in a room exceeds 0.6 volumes per 1000, the air gives a distinct feeling of tightness to a person entering from outside, and it is usual to adopt this as the standard of purity. The amount present in pure air is 0.4, and the object of ventilation is to prevent the CO_2 from exceeding 0.6 per 1000. De Chaumont holds that vitiation to the extent of 0.2 per 1000 and not greater may be allowed with impunity. Hence the *permissible limit* of respiratory impurity is 0.2 per 1000 or 0.0002 cubic ft. of CO_2 per one cubic ft. of air. The amount of CO_2 varies with the weight and activity of the person. For a mixed community 0.6 cubic ft. of CO_2 per hour may be taken as the general average, and for adult males 0.7.

By dividing the amount of CO_2 exhaled in an hour by the permissible limit of respiratory impurity, De Chaumont estimated the number of cubic feet of air per hour required for each person. This is the standard now accepted, and is expressed as under :—

$$\frac{e}{p} = d,$$

Where $e = CO_2$ exhaled in an hour per head, *i.e.* 0.6 cubic ft.
$p =$ limit of respiratory impurity per cubic foot (*i.e.*, 0.0002 cubic ft.).
$d =$ the delivery or amount of fresh air available in cubic feet per hour.

Therefore $\frac{0.6}{0.0002} = 3000$, the number of cubic feet of air necessary for every individual of average weight per

hour. This formula may be used conversely to find out from the condition of the air the amount of fresh air that has been supplied and utilised. But for this purpose we substitute p_1 for p (the limit of respiratory unit), the observed ratio: thus, $\frac{e}{p_1}=d$.

Suppose total CO_2 in a room is 1.1 per 1000, or 0.0011 per cubic foot, it is 0.0004 in the atmosphere: therefore p_1 is $0.0011-0.0004$ or 0.0007: thus $\frac{e}{p_1}=d$ or $\frac{0.6}{0.0007}=857$ cubic feet of air supplied.

By transposing the last formula we can calculate the probable state of the air of a room into which a known quantity of air has been or is being admitted. Thus $\frac{e}{d}=p_1$.

If five persons occupy a room with a capacity of 6000 cubic ft. for 6 hours, and allowing 8000 cubic ft. of air per hour, what would be the percentage of CO_2 at the end of the hour?

Each person gives off 0.6 cubic ft. of CO_2 per hour. Therefore $0.6\times5\times6=18$ cubic ft. of CO_2 for five persons in six hours.

Thus $\frac{e}{d}=p_1$ becomes $\frac{18}{54000}=p_1$, or 0.00033 per cubic ft. or 0.033 per cent. An adult man during exertion as in doing hard work may give out about 1.6 cubic ft. of CO_2 hourly, consequently a greater amount of fresh air is necessary.

The average hourly exhalation of carbon dioxide for a child is 0.4 cubic ft., for an adult male 0.72, and for a woman 0.6.

An adult male requires about 3000 cubic ft. per hour.
A child ,, 2000 ,, ,,
In a mixed community 3000 cubic ft. are required.

2. **Amount of Air required for the Sick.**—For sick persons in hospitals the amount of fresh air should exceed that required by the healthy at least by one-fourth. For

instance, if 3000 cubic ft. be the average in health, 3750 cubic ft. will be required in sickness per hour.

3. **Amount of Air required for Combustion.**—An ordinary flat-flame gas burner which generates about 2½ cubic ft. of CO_2 will consume 5 cubic ft. of gas per hour, 1000 cubic ft. of air are needed for every cubic foot of CO_2 per hour. Therefore about 2250 cubic ft. of fresh air must be supplied per hour for each gas burner in a room.

The following table modified from Notter and Firth shows the relative amount of oxygen removed from the air, carbon dioxide given off, and quantity of carbon consumed, per hour by various forms of artificial light :—

	Quantity consumed.	Oxygen removed	CO_2 produced	Vitiation equal to adults
Tallow candle	2200 grs.	10.7 c. ft.	7.3 c. ft.	12.0
Kerosene oil lamp	909 ,,	5.9 ,,	4.1 ,,	7.0
Coal gas	5.5 c. ft.	6.5 ,,	2.8 ,,	5.0
Coal gas (incandescent)	3.5 ,,	4.1 ,,	1.8 ,,	3.0
Electric light (incandescent)	0.3 lb. coal	0.0 ,,	0.0 ,,	0.0

It will be seen from the above table that the electric incandescent lamp is the best light from a hygienic point of view ; all other lights, being more or less dependent upon the absorption of oxygen from the air, vitiate the atmosphere by certain products which affect the health to a greater or less degree.

4. **Amount of Fresh Air required for Animals.**—Animals require fresh air as much as men do. A horse or a cow ought to have about 10,000 to 20,000 cubic ft. of air per hour, in the ratio of 20 to 25 cubic ft. per hour for every pound of body weight.

Methods by which the Required Amount of Fresh Air can be Supplied

Practical ventilation is an engineering problem, but the conditions of ventilation can never be the same, owing to the fact that the rooms and houses requiring ventilation vary greatly. No single system, therefore, is

applicable to all. But the fundamental principles are more or less the same.

The physical theory of ventilation may be stated in two propositions :—

(*a*) Given a "head of air," a continuous flow can be maintained through a room, the amount of air entering and leaving being equal.

(*b*) A "head of air" is produced by difference of pressure between the air within and the air without the room.

Now the question is how to produce such a head of air, or more appropriately how to provide each individual with approximately the quantity of air mentioned above?

Systems of Ventilation

In any system of ventilation the size and shape of the room are important factors requiring consideration. This however in dwellings, workshops, factories, schools and dormitories is an economic question. But in any case the room should be large enough to allow the air to be replaced two or three times an hour without any perceptible draught. Taking this as the standard the minimum space is about one-third the quantity of air required per hour, *i.e.* from 700 to 1000 cubic ft. per person. The student should remember that air space by itself has little value unless the air is replaced by free circulation of fresh air. Haldane and Osborne have shown that CO_2 bears no relation to the amount of air space under practical condition.

Ventilation may be calssified into

A. Vacuum System.

B. Plenum System.

These involve either the extraction or propulsion of air in the room to be ventilated, and are ordinarily classed under the name of *artificial* ventilation. The common division into *natural* and *artificial* or *mechanical system* is quite inappropriate, since the so-called natural systems are artificial in a high degree, and the mechanical systems involve practically the same principles.

A. **Vacuum or Extraction System** :—

1. **Open Fire with Flue.**—The principle underlying this system is that heat expands the volume of air, reduces the density, and thus causes an upward flow which in turn sets up a current in the room-air. Ordinary fireplaces, chimneys, and ventilating gas lights act in this way. The efficiency of ventilation depends upon the difference between the temperature inside the room and the temperature of the air outside. Mines are usually ventilated in this way by lighting a fire at the bottom of an upcast shaft. The main point to remember in this system is that the fire should be put at the bottom of the upcast shaft and provision made at suitable points for free admission of pure air. By this method about 1000 to 2000 cubic ft. of air are supplied per head per hour, but in mines where fire damp is evolved as much as 6000 cubic ft. of air per hour per man are given.

In cold countries many public halls, hospitals and other large buildings are ventilated by this method of extraction.

2. **Inlets and Outlets.**—The openings through which ventilation is carried out are known as inlets and outlets. Inlets are intended for the entrance of pure air and the outlets for the escape of vitiated air. This method of ventilation is known as " natural " ventilation.

In warm climates the doors and windows supply all the necessary ventilation, and in some instances pervious walls, as of bamboo matting allow free perflation without any harm whatever. In colder climates the doors and windows have to be closed and special arrangements must be made for inlets. The chimney serves the purpose of an outlet, but if insufficient other outlets must be provided.

(*a*) *Inlets.*—The chief point with regard to the inlet openings is that they should be selected in such positions that the air supplied be pure and not polluted before admission. In India where ventilation is carried out through doors and windows, these should as far as possible be on opposite sides of the room. Where special inlets are provided they should be near the floor, and from 24

to 48 square in. in area for each person. When the supply of air is cold, as in the hill stations, the current of air to which the body is exposed will be felt as a draught and might be intolerable. But the current may be allowed to enter without causing discomfort, provided its direction keeps it from striking directly on the persons of the inmates. To secure this it should enter vertically through

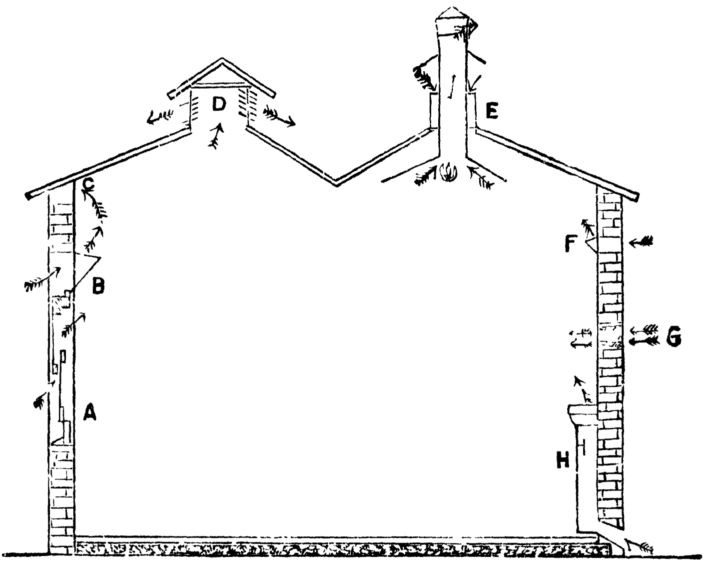


FIG. 7. (After Parkes and Kenwood.)

Sketch of various provisions for ventilation. A, Sash window. B, Hopper sash-light falling inwards. C, Ridge ventilation. D, Louvred outlets. E, McKinnell's ventilator. F, Sheringham's valve. G, Ellison's conical bricks. H, Tobin's tube.

openings high enough to carry the stream into the upper atmosphere of the room where it would at once mix with warm air before its presence could be felt.

The common forms of inlets, generally used in cold countries are :—

1. *Double Sash Window* with an air space between. Swinging windows are often employed as inlets especially in hospitals and schools.

2. *Louvres or ventilators* made on the principle of ventilation blinds. These can be opened or closed at will by a mechanical arrangement.

3. A hinge at the upper part of the window so that it can fall forward and act as a Sheringham's valve.

4. *Bricks perforated with conical holes* with the narrow end outside. The air passing through the narrow to the broad end is so distributed that it is not felt as a draught.

5. *Tobin's Tube.*—It is a short vertical shaft of metal plate or wood which leads up the wall from the floor level to a height of 5 or 6 ft. The lower end opens into the outer air through an air brick or an opening made in the wall; the current of fresh air rises in a smooth stream through the upper opening and it does not seem to change its direction until it has gone far above the opening.

6. *Sheringham's Valve.*—This is a flap door placed near the ceiling, and when opened it forms a wedge-shaped projection into the room, and admits air through the open top in an upward direction.

7. *McKinnell's Ventilator* consists of an inner and outer tube, one encircling the other, the inner forming the outlet tube, and projecting beyond the outer both outwards and inwards.

(*b*) *Outlets.*—As a general principle the outlets should be placed opposite to the inlets. Respired air has a tendency to go upwards and outlet openings are best provided at the upper part of the room. Rooms with sloping roofs can have outlets in the form of *ridge-openings* along the entire top as in the case of Indian huts. In tropical climates windows are placed opposite to each other which act both as inlets and outlets.

The regulation of the ventilation openings is of some importance. In colder climates it is better for the windows to open at the top with a slope from below upwards and inwards, so that the cold air may be directed upwards and then sink by its own weight. In India the windows almost always open either outwards or inwards,

and consequently the regulation of the direct force of the wind is not very easy. By keeping the venetians partly closed, and the inner glass windows open, excess of light and wind may be prevented from entering the room.

B. **Plenum or Propulsion System** :—

In this system fresh air is driven into rooms by mechanical forces like revolving fans, stoves, steam-heated coils, steam jets or other appliances. The fans used for propelling the air are known as " blowers," and consist of large and curved blades set obliquely on a rapidly revolving axis. These are driven by gas, steam, or electricity. This mechanical system of plenum ventilation is sometimes adopted in public halls, etc., where the cubic space per head is necessarily small.

1. **Propulsion by Steam Jet.**—The force of the steam jet forms the motive power. Tubes passing from adjacent rooms converge into the chimney below the steam jet and the upward current extracts air from them. This plan is very suitable in factories where there is a spare supply of steam.

2. **Propulsion by Means of Pumps.**—This is used in some collieries for forcing in fresh or extracting foul air. Seldom used for ventilating buildings.

The advantages of artificial methods of ventilation are the constancy and facility with which fresh air is supplied under all conditions, whereas natural ones though less costly are not under the human control being subject to atmospheric conditions.

It should be noted that where the cubic space is large there is less need of frequently changing the air. For a single man a room having an area of 100 cubic ft., the air should be changed thirty times per hour if 3000 cubic ft. of air be given a procedure which would cause a very disagreeable draught in cold-weather, whereas if the area of the room be 1000 cubic ft. the air requires to be changed only three times per hour for equal ventilation without creating any perceptible draught. By suitable arrangements of windows, etc., about half a dozen changes of the air of a room can be made without any draught being felt.

The authorised amounts of space alloted per head are as follows :—

Soldier	600 cubic ft.	
Dormitories of poor houses	300 ,,	(healthy person)
,, ,, ,, ..	850 to 1200 cubic ft.	(sick person)
Poor-law schools ..	360 cubic ft.	
Registered lodging houses	300 cubic ft.	(above 10)
,, ,, ,, ..	150 ,,	(under 10)

The allowable minimum floor space should not be less than one-twelfth of the cubic space.

Purification of Air

Purification of air may be brought about by both natural and artificial methods. The natural methods are very important and are as follows :—

1. **Rain.**—This carries dissolved or suspended impurities to earth as evidenced by an increase in the amount of ammonia, etc. Rain is in fact a mechanical purifier and washes the air.

2. **Plants.**—The green parts containing chlorophyll take in CO_2 from the air and assimilate carbon and give off oxygen to the atmosphere.

3. A few constituents that enter into the composition of the atmosphere help also to purify the air. These are *oxygen* and *ozone*. The ammonia and organic impurities are washed down with the rain as nitrites and nitrates.

4. **Ventilation**, *i.e.* the interchange of pure and impure air. Besides the methods already described by which ventilation is carried on, there are three other *forces concerned in ventilation*, viz. diffusion, winds, and differences of temperature of masses of air.

(*a*) *Diffusion.*—Gases diffuse inversely as the square root of their densities. It has been shown by Pettenkofer and Roscoe that diffusion takes place in a room which is not air-tight, the air moving in and out in every possible direction, either through bricks, chinks and crevices of doors and windows, etc. But under ordinary

circumstances the diffusion, if there be any, is very small. and organic substances, which are not gaseous, but molecular, are not at all influenced by it. Therefore diffusion as a ventilating agent is inadequate.

(*b*) *Winds.*—Wind is a very powerful ventilating agent. Ventilation is carried out partly by what is called perflation, and partly by aspiration. Certain objections may be raised against winds as ventilating agents. They are :—

(i) The air may be very stagnant, and consequently ventilation becomes most imperfect.

(ii) The difficulty of regulating the velocity of the current, which by blowing very heavily against an exit shaft, may impede ventilation by obstructing the outlet of air.

The perflating power of the wind has in some systems of ventilation been used as a motive power, especially in the ventilation of holds and cabins of ships at sea. The wind is conducted below by means of tubes with cowls so arranged as to face the wind, the vitiated or used air escaping through a different opening. The aspirating power of the wind and the production of a head of air, when wind blows over the top of a tube, can be secured by covering air shafts with cowls, which while assisting up currents prevent down currents. No cowl, however, is effective save that it prevents foreign bodies, birds, rain, etc., from entering into the shaft. Some are rotatory, and the disadvantage is that these are active in a high wind when they are not needed and are stationary and obstructive in a calm when they are wanted. In Indian towns where narrow lanes are abutted by high buildings ventilation in the lower rooms becomes necessarily imperfect. Movement of air in such rooms can be best ensured by large metal pipes inserted through the roofs with funnel-shaped mouth turned towards the wind.

(*c*) *Effects of differences of Temperature of Masses of Air.*—Unequal temperature causes unequal weights in masses of air. If the air of a room be heated by fire or by products of respiration of men and animals, or be made more or less moist, it tends to expand, and rises up or

escapes through other openings. The outer colder air rushes in through every opening until the temperature of both outside and inside air becomes equal. But the incoming fresh air in its turn becomes heated and so a constant current is maintained. In India when the air is very stagnant and the difference of temperature between the external and internal air is almost nil, ventilation is more imperfect and heat is correspondingly increased. This is very common in large buildings like town halls, etc., when they become crowded.

Artificial Methods.—These are sometimes adopted to render air fit for respiration, but it must be considered as supplementary to ventilation. Certain substances act chemically on air: thus charcoal is used to purify the air issuing from drains and cesspools, but to be of any use the charcoal should be dry. Unslaked lime is used to absorp CO_2 in wells, etc.; copper sulphate removes the odour of H_2S; solution of lead nitrate removes H_2S from cesspools, and solution of zinc chloride destroys organic matter. Solution of permanganate of potash destroys organic matter and ammoniacal compounds, and absorbs H_2S.

Examination of Ventilation of a Room

The amount of ventilation in a room can be calculated by the following means:—

1. Determine the amount of cubic space and floor space alloted to each person and the rate of movement of air.

2. Examine the air by chemical, bacteriological, and mechanical methods, and by the senses. Estimate the amount of suspended matters, organic impurities, etc.

3. Note the number, size, and position of the inlets and outlets, and the amount of air entering and leaving the room, and particularly whether the distribution is thorough.

4. A thorough examination of the building and its surroundings must be made with a view to the discovery of rubbish, foul drains, latrines, etc.

Determination of the Amount of Cubic Space.—This is done by multiplying the length, breadth, and height where the room is regular in shape. Where the rooms are irregular in form with angles, projections, etc., certain rules for measurements of the areas of circles, segments, triangles, etc., must be followed. It is seldom necessary to make deductions for furniture like chairs, tables, and other furniture that occupy only a small space. But deductions must be made for the bodies of persons living in the room and for solid furniture like cupboards, bedding, etc., which occupy a certain amount of space. Recesses containing air should also be measured and added to the amount of cubic space. The cubic contents of a room can be determined by any one of the following rules:—

Circumference of a circle = diameter (D) $\times$ 3.1416.

Area of a circle = $D^2 \times 0.7854$.

Area of an ellipse = product of the two diameters $\times$ 0.7854.

Circumference of an ellipse = half the sum of two diameters $\times$ 3.1416.

Area of a square = square of one of the sides.

Area of a triangle = base $\times \frac{1}{2}$ height, or height $\times \frac{1}{2}$ base.

Area of a parallelogram = divide into two triangles by a diagonal, and take the sum of the areas of the two triangles.

Cubic capacity of a solid rectangle or a cubic found by multiplying three dimensions together.

Cubic capacity of a cylinder = area of base $\times$ height.

Cubic capacity of a cone or pyramid = Area of base $\times \frac{1}{3}$ height.

Cubic capacity of a dome = Area of base $\times \frac{2}{3}$ height.

Cubic capacity of a sphere = $D^3 \times 0.5236$.

The number of cubic feet of space per head is determined by dividing the total number of cubic feet (after necessary additions and deductions) by the number of persons occupying the room. The floor space per head is determined by dividing the total area of the floor by the number of persons.

The rate of movement of the air in a room is determined by first ascertaining the direction of the air. It is necessary at the outset to enumerate the various openings of the room acting as inlets and outlets, which will furnish a key in determining the direction of the movement of the air. Inlets are distinguished from outlets by noting the direction of the smoke disengaged from smouldering brown paper or cotton velvet when held close to the openings.

Heating and Cooling

We have now to consider the problems pertaining to the heating and cooling of houses. This subject is intimately related to ventilation as difference of temperature is one of its causes. Heating of dwelling houses in India is restricted to certain hill stations, and even there only in winter. The opposite process of cooling the houses and atmosphere is more a necessity in India than that of heating. The means of producing heat are many, while the methods of keeping the rooms and air cool are not only very limited but unsatisfactory in the extreme. A short description, however, of both these methods is given below:

1. **Distribution of Heat.**—For the purposes of heating houses and of ventilation heat is commonly produced by the combustion of fuel, and is distributed by:-

1. Conduction.
2. Radiation.
3. Convection.

1. **Conduction.**—Solids are good conductors of heat, while liquids and gases are bad ones. Good conductors give off heat rapidly to the surrounding air and to other articles in contact with them. This process is very slow as air is a bad conductor of heat.

2. **Radiation.**—By this is meant the giving off of heat from hot bodies, such as open fireplaces to colder ones through the air. During radiation heat is transmitted in straight lines on all sides with equal intensity. The

intensity of the radiant heat is in inverse ratio as the square of the distance. Thus if the heat at 1 ft. distance from a fire be one, then at 4 ft. it will be sixteen times less.

3. **Convection.**—By this process heat is transmitted through gases and liquids. Convection depends upon a peculiar tendency of these bodies to expand with heat and thus become lighter and rise upwards, their place being taken up by colder and heavier portions, which in their turn become warm, expand and ascend, thus setting up a process of circulation of hot air in every part of the room.

The common methods of heating dwellings are :—

(*a*) Open fireplaces and grates.

(*b*) Closed fires or stoves.

(*c*) Pipes charged with hot air, hot water, or steam.

(*a*) *Open Fireplaces.*—This method is most extensively used in England and in the hill stations in India on account of the cheerfulness of the room and efficient ventilation which it ensures.

(*b*) *Closed Fires or Stoves.*—In this method heat is obtained by burning fuel in a grate enclosed by a good conducting or absorbing material on all sides except below the bars. The air coming in contact with this heated surface becomes warmed and thereby heat is disseminated. These stoves are usually made of cast iron, bricks or tiles. Coal, coke, paraffin, etc., are burnt in these stoves.

The objections to the above method are :—

(i) The coal makes the air hot and dry.

(ii) A peculiar close smell, due to the decomposition of organic matter, is present.

(iii) Products of combustion, *e.g.* carbon monoxide, escape through the stove.

But all these objections can be effectively met with by using a ventilating or a properly constructed gas stove with a suitable flue.

Gas Stoves.—These are good for cooking and in cases where heat is required quickly and for a short time only. Gas stoves should always have a flue, otherwise the

products of combustion left in the room might affect the health of the occupants.

(*c*) *Heating by hot air, hot water, and steam* are also resorted to, but are not ordinarily adopted in India.

II. **Artificial Cooling of Air.**—This is most important in India, and excepting the different hill stations cooling of the atmosphere and of the rooms is specially called for during the summer months. This is generally done by preventing direct radiation of the sun from entering the room, and by keeping the doors and windows closed during the day time. By this method the air inside the house is rendered much cooler than the air outside, and a circulation is thereby established. The outside air can be made cooler by passing it by means of Thermantidotes or fan-

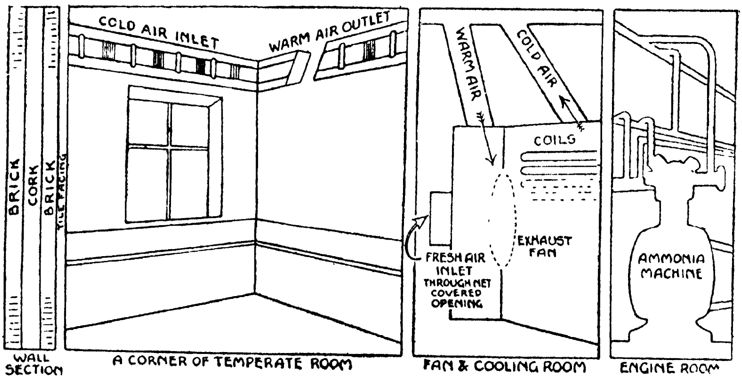


FIG. 8.—Artificial Cooling of Room.

wheels through wet *khus-khus* mats or *tatties* which will have the additional effect of acting as filters by removing all suspended impurities of air. These are hung over doors and windows, and frequently wetted by sprinkling water on them. The evaporation of this water effectively cools the air of the room. Fans and punkahs though used as propellers also help to keep the room cool. By condensation and rarefaction of air certain changes in the temperature may be produced. By suitable arrange-

ments of expansion cylinders, it is possible to have a supply of cold air, the temperature of which is much below that of the surrounding bodies. This method of cooling is utilised in refrigerating chambers in ships carrying meat. Experiments made at the Calcutta School of Tropical Medicine in buliding what is known as the temperate room seem to hold great possibilities in the temperature of the hot months. This room is kept at a temperature of 70° to 75° F. and is provided with inlets for cold and outlets for warm air. The cold air passes through a pipe connecting the room with an adjoining room, the fan room, and the warm air goes out by another pipe which is discharged near the fan and passes over the coils into the cold air inlets leaving moisture behind (*See* Fig. 8). The fan has a wire protected operation for the supply of fresh air from outside free from dust. This also passes over the coils before reaching the cold air pipe. Next to the fan room is the ammonia machine room worked by a low speed motor. There is thus a constant circulation of air. Heated air is being continually drawn off and returned again in the form of cool fresh air. There is no risk of chills, and by the provision of fine netting over the inlets and outlets germs and mosquitoes are also eliminated.

CHAPTER IV

OCCUPATIONAL DISEASES AND OFFENSIVE TRADES

Within recent years industrial hygiene has assumed a most important position in preventive medicine owing to the enormous progress made with regard to different industries. This deals with the health, the welfare, and the human rights of the vast majority of the population. New problems have been introduced largely through the development of new industries and the invention of newer processes. Thus, we have the mining industries where the miner is compelled to work underground, and therefore the mortality from accidents and diseases of the lungs is high. Coalminers phthisis and anthracosis are well known diseases. The jute and cotton mills, where the workers are exposed to dusty occupation for several hours, and thus become early victims to different diseased conditions. Liability to plumbism in the manufacture of white lead; necrosis of the jaw in the manufacture of matches; and the risk of life and limb in those working in mills, railways, mines, etc. The dangers of inhaling irritating fumes from different suspended impurities, gases and effluvia (*see* p. 63-64); and finally the risk of infection from anthrax and hookworm disease. These are all typical occupational diseases. Apart from all these there are other conditions, though not directly related to industries, which seriously affect the health of the workers. These arise from poor ventilation, lack of cleanliness, overcrowding, faulty lighting arrangements, etc.

In order therefore to improve the sanitary condition of the people working in different industries certain rules have to be followed for the welfare of the workmen. The following require careful consideration :—

1. *Hours of Work.*—These require careful consideration, and should be regulated according to the nature of

work, the physical exertion required, and also upon the nervous tension. Special consideration should be shown to women and children. Pregnant women should not work for several weeks before and after confinement. On account of age, boys under eighteen years should not be taken in works involving danger to health from irritating dust or poisonous fumes.

2. *Periodical Inspection.*—This is necessary for the protection of the workmen. During these inspections the conditions under which the work is carried on, and the workmen live outside the working hours, require very careful supervision. Ventilation, dust, cleanliness, gases, vapours, heat, dampness, light, overcrowding, drinking water, washing facilities, latrines, sanitary arrangements, hours of work and rest, etc., all require to be investigated.

3. *Accidents.*—These are common in those working in railways, mines and in factories, and with proper care it is possible to reduce these to a minimum. Certain special injuries or diseases are common to workmen. For instance, spinal curvature due to faulty posture, varicose veins from long standing, injuries to the eye from fragments of stone or metals, impairment of vision from faulty lighting, or eye strain, etc.

In the year 1911 an Act was passed known as the Indian Factories Act (Act XII of 1911) to improve the hygienic conditions under which the people work, and also to take measures to prevent diseases incidental to particular occupation. By this act the local Governments have power to appoint inspectors with certain powers, to regulate hours of work, and adopt sanitary measures with regard to ventilation, lighting, water-supply, latrine and urinal accommodation, provision for means of escape in case of fire, precautions against fire and accidents, and general cleanliness as will be conducive to the health and welfare of the factory hands.

Occupational Diseases

Lead.—Lead is a cummulative poison and being an important article of commerce it is a most common and

insidious of all occupational diseases. The poison gains entrance into the system by (*a*) swallowing minute particles of lead ; (*b*) inhaling dust and fumes of lead when in a molten state ; and (*c*) absorption from the skin in handling lead. Chronic poisoning originates from the slow absorption and retention of minute quantities of the metal. Workers in lead factories and those who constantly handle lead are very prone to poisoning as they generally contaminate their food by their unwashed hands. The preventive measures should consist of cleanliness of the hands and finger nails, frequent bathing and the use separate clothing while at work, and to thoroughly wash the hands and rinse the mouth before eating. Avoid taking any food in the workroom or where there is suspicion of lead in the air. Good nutritious food with plenty of milk and avoidance of all excesses, specially alcohol. The workshop should always be kept clean, well-ventilated, and free from dust. Arrangements should be made for rapid and complete collection of all fumes and dust which should be conducted to condensing chambers.

Mercury.—Persons engaged in the preparation of vermilion, barometers, thermometers, and workers in factories where mercurial salts are either prepared or handled, expose themselves to the poisonous effects of the metal.

The sanitary precautions to be observed are similar to those mentioned in the case of lead. Workmen should be provided with overcoats. Special attention should be paid to the proper care of the mouth and teeth and all carious teeth should either be removed or filled. Metallic mercury vaporises even at the ordinary temperature and may produce poisonous effects ; it should therefore be kept covered to lessen the emanations as far as possible. The floors should be so constructed as to render the collection of all spilt mercury easy.

Phosphorus.—It is used chiefly in the manufacture of matches, and poisoning occurs only in those who expose themselves to its fumes. They suffer from necrosis of the jaw, or from a characteristic cachectic condition with anæmia, dyspepsia, albuminuria and bronchi-

tis. Fragilitus ossium is also found in those working in phosphorus.

Precautions.—As far as possible the use of yellow phosphorus, which is more poisonous, should be discouraged and substituted by sesquisulphide of phosphorus which is harmless. The safety match contains no phosphorus and is harmless. "The strike any where" match may be made with non-poisonous sesquisulphide of phosphorus instead of the poisonous white phosphorus. The fumes of white and yellow phosphorus are rich in oxides and are absorbed.

Special care should be taken for the teeth, and those with carious teeth are particularly susceptible to its action. Rigid personal cleanliness should be observed and washing out of the mouth with alkaline solutions encouraged. The work should be carried out in large, well-ventilated rooms, and if possible in the open air. The inhalation of turpentine with a view to oxidise phosphorus is also recommended.

4. **Arsenic.**—Poisoning occurs amongst those who either handle arsenical pigments, inhale arsenical dust from wall-papers, or are engaged in the making or manufacture of articles coloured with arsenical dyes, *e.g.* artificial flowers, or those who prepare skins of animals for stuffing. The workers suffer from painful redness of the eyes, irritation of the skin, eczema, neuritis, vomiting, headache, etc.

The sanitary precautions necessary are similar to those described under lead poisoning.

Offensive Trades

Certain trades require to be supervised by sanitary officials, partly on account of their being a source of nuisance because the smell or effluvia which they give off might act injuriously on the health of the people, and partly also on account of the materials or processes employed having an influence prejudicial either to the health of the workmen or the surrounding populations.

According to the Bengal Municipal Act III of 1884 the following offensive trades are not to be established without a license.

(*a*) melting tallow ;
(*b*) boiling offal or blood ;
(*c*) skinning or disembowelling animals ;
(*d*) as a soap house, oil boiling house, dyeing house ;
(*e*) as a tannery, slaughter-house ;
(*f*) or kiln for making bricks, pottery, tiles or lime ;
(*g*) as a manufactury or place of business from which offensive or unwholesome smells may arise ;
(*h*) as a yard or depot for trade in hay, straw, wood, thatching grass, jute or other dangerously inflammable material ;
(*i*) as a store-house for kerosene, petroleum, naphtha, or any inflammable oil or spirit ;
(*j*) as a shop for the sale of meat ;
(*k*) as a place for storage of rags or bones, or both ; or
(*l*) as a lodging house or a serai.

The effluvia arising from tallow melting, offal boiling, soap boiling, bone crushing, shell burning, and lac dye making are offensive, and according to Ballard give rise to headache, nausea and diarrhœa. Unless proper precautions are taken and arrangements made for the disposal of liquid refuse, offensive trades such as tanneries, bone-boiling, etc., should not be located near any river or other sources of water-supply.

1. **Keeping of Animals.**—In rural districts the keeping of animals is not likely to cause much nuisance ; it is only when they are kept in crowded, ill-ventilated, and badly drained localities in towns, that the emanations become a source of nuisance. Pigs, horses, cows, etc., often create a nuisance chiefly from the storing of grains and other foodstuffs in a wet state and the accumulation of dung and soakage of urine, etc., into the ground owing to imperfect or defective flooring. Cowsheds, stables, etc., should therefore be properly constructed (which see). The discharges should be received into covered vessels and the sheds should be washed and cleaned daily.

Pigsties also create a serious nuisance from the smell of the sour and decomposed rice on which the pigs are usually fed. The food should be stored in impervious vessels with proper covers. The sties are as a rule kept in a very filthy condition.

The keeping of poultry is also a source of nuisance and should be discouraged in small houses and cellars.

2. **Slaughtering of Animals.**—Slaughter houses may be either *private* or *public*. Private slaughter houses, as conducted in this country should be discouraged, as they not only facilitate the slaughtering of diseased animals, but are generally a source of very serious nuisance especially when not managed under proper supervision. Nuisances arise from the dirty way in which the animals are usually kept. The storage of decomposed carcases and garbage also add to filthiness.

Slaughter Houses.—Filthy slaughter houses are always a menace to public health owing to the large collection of offal undergoing putrefaction, and the continual flow of blood, urine and fæcal matter. It is essential for proper sanitary control that all slaughtering should be done in a public slaughter house or "abattoir." These should be built with brick and concrete and well protected against rats. In the construction of a slaughter house the following points should be noted :—

1. It should not be within a hundred feet of any dwelling-house, and should be open to the air at least on two sides.

2. It should always be above the ground level.

3. There should be no room or loft over the slaughter house.

4. There should be an abundant supply of water, and the cistern for storing water should be placed a few feet above the floor.

5. The floor should be made of some impermeable material with a proper slope and a channel to a gully, provided with a trap, to prevent emanantion of offensive gases from entering the slaughter house.

6. The walls in the interior should be covered with hard, smooth and impervious material to a man's height.

The corners should be rounded off, and the slightest openings on the floor repaired without delay.

7. There should be no direct connection between a water closet or privy within the slaughter house.

8. Doors and windows should be self-closing and have wire netting to prevent flies and other insects from entering.

9. Dogs should not be allowed around the slaughter house on account of the danger of *trichinosis* and other parasites.

10. The employees must be cleanly and wear clean outer clothes.

11. Persons suffering from any communicable disease, like tuberculosis, should not be allowed to handle any meat or meat products.

12. Butchers who handle diseased carcases should wash their hands in some disinfectant solution, and all instruments used must be sterilised.

All refuse, blood, manure, and garbage are to be placed in vessels of non-absorbent materials with close-fitting covers immediately after slaughtering to prevent vultures and other birds from scattering them about. All skins, fat, etc., are to be removed from the slaughter house as soon as possible.

3. **Blood-boiling or blood-drying.**—Blood collected from slaughter houses is utilised for (*a*) making blood albumin, (*b*) manufacturing turkey red pigment, (*c*) preparing blood manure, and (*d*) refining sugar.

Sanitary precautions.—The floor, vessels, etc., should be kept scrupulously clean, and blood, when not in use, should be properly stored to prevent the escape of offensive gases. There should be proper arrangements for drianage and for the condensation of escaping gases, which are usually offensive.

4. **Bone-boiling.**—This is rather common in this country owing to increased demand for phosphatic manures in tea gardens. The accumulation of bones in a raw state soon becomes offensive, especially during the summer and rains. The storage of raw bones should not be permitted in or near dwellings, as the odours given off are

very disagreeable. Bone-boiling, when the bones are perfectly fresh, is no more offensive than cooking on a large scale. But if the bones are tainted and decomposed they give rise to a very serious nuisance. Putrid bones, hoofs and horns, if left in the open, become extremely offensive and breed flies and cause sickness.

Sanitary precautions.—The premises should be cleansed daily and all refuse collected and removed. All receptacles should be kept clean, and materials not for immediate use should be stored in such a way as will prevent effluvia. Keep the walls and floors in good order and lime wash twice a year. Storing of bones should be in suitable sheds and the use of steam jacketed cylinders for condensing vapours enforced.

5. **Gut-scraping.**—This is generally done for the purpose of making sausage skin, catgut, etc. The small intestines of swine and sheep are first washed and cleaned and softened by soaking in salt solution for a few days, and then scraped on a bench with a piece of wedge-shaped wood until a little of the muscular coat and the peritoneal covering only are left. These are finally washed and dried.

Nuisance is prevented by (*a*) making the floors and walls of non-absorbent materials ; (*b*) proper drainage arrangements ; (*c*) providing marble-topped tables ; (*d*) prompt removal of waste materials ; (*e*) careful washing and cleaning of the premises ; and (*f*) preventing improper and prolonged storage.

6. **Fat and Tallow Melting (soap-boiling).**—Fat is usually obtained from butchers or marine store dealers in a more or less decomposed condition. It is utilised in the manufacture of candles, soaps, leather-dressings, and preparations for lubricating machinery. The fat "is melted either in pans (*a*) heated by an open fire, or (*b*) in pans which are steam-jacketed, or (*c*) by free steam and sulphuric acid." *Tallow* is beef or mutton fat, or a mixture of both prepared and melted by one or other of the above means.

Nuisance may arise from (*a*) improper conveyance or storage of meterial, (*b*) storage of residue, (*c*) general

filthiness and unsuitability of the premises, and (*d*) vapours escaping during the process of melting or boiling the fat.

7. **Fellmongering and Leather-dressing.**—A fell-monger prepares either fresh or old skins for the leather dresser and a leather dresser or tanner converts the skins into various kinds of leather. The fresh skins are first beaten to get rid of the dirt, and then soaked in water and washed. The hair is removed by the addition of lime. The old or foreign skins are first softened by soaking in water until decomposition sets in, when the hair or wool becomes loose and is removed. This is known as the "tanning process." The skins devoid of hair are known as "pelts" which are thrown into a pit containing milk of lime. They are then taken to the leather dresser or tanner. By the process of "tanning" the putrescible hides are converted into non-putrescible and more or less flexible materials commonly known as "leather." The leather is rendered soft and waterproof by treating with fatty and other materials. Tanneries, when conducted on European models, are not, as a rule, productive of much nuisance. Still on account of the offensive odours they give out they should be located on the outskirts of the town. Small tanneries are usually productive of great nuisance, which is heightened by the wash water, largely impregnated with decomposing animal matter, being allowed to run into open surface drains or into waste lands and hollows.

Hence nuisances arise from (*a*) filthiness or unsuitability of the building, (*b*) improper conveyance or storage of skins, and (*c*) unsatisfactory method of disposal of the dirt, flesh, and waste water. All offensive materials should therefore be conveyed in non-absorbent covered receptacles and kept in special, closed rooms ventilated by means of air-shafts. General precautions are the same as before indicated for other trades.

8. **Paper-making.**—Paper is prepared from such substances as cotton or linen, rags, waste paper, straw, bamboo, esparto grass, etc. The rags are first dusted and then cut into small pieces, washed and bleached. Esparto grass is reduced to pulp by first boiling with caustic alkali.

Nuisance is caused chiefly by the esparto liquid, which should not be allowed to run into any stream or ditch near habitations. The collection and storage of the materials is also a source of danger to the public health. The vapours given off during the process of boiling esparto grass with caustic alkali are also offensive and should be conducted by a flue to a tall chimney.

THE INDIAN FACTORIES ACT, 1911 (ACT XII OF 1911)

AS MODIFIED UP TO THE 1ST JULY, 1922

SEC. 3 —(3) " factory " means—

(*a*) any premises wherein, or within the precincts of which, on any one day in the year not less than twenty persons are simultaneously employed and steam, water or other mechanical power or electrical power is used in aid of any process for, or incidental to, making, altering, repairing, ornamenting, finishing or otherwise adapting for use, for transport, or for sale any article or part of an article ;

or (*b*) any premises wherein, or within the precincts of which, on any one day in the year not less than ten persons are simultaneously employed and any such process is carried on, whether any such power is used in aid thereof or not which have been declared by the Local Government, by notification in the local official Gazette, to be a factory.

INSPECTORS AND CERTIFYING SURGEONS

4. (1) The Local Government may, by notification in the local official Gazette, appoint such persons as it thinks fit to be inspectors of factories within such local limits as it may assign to them respectively.

(2) No person shall be appointed to be an inspector under sub-section (1), or having been so appointed, shall continue to hold the office of inspector, who is or becomes directly or indirectly interested in a factory or in any process or business carried on therein or in any patent or machinery connected therewith.

(3) The District Magistrate shall be an inspector under this Act.

(4) The Local Government may also, by notification as aforesaid, and subject to the control of the Governor General in Council, appoint such public officers as it thinks fit to be additional inspectors.

5 Subject to any rules in this behalf, an inspector may, within the local limits for which he is appointed,—

(*a*) enter, with such assistants (if any) as he thinks fit, any place which is, or which he has reason to believe to be, used as a factory ;

(*b*) make such examination of the premises and machinery and of any prescribed registers, and take on the spot or otherwise such evidence of any persons as he may deem necessary for carrying out the purposes of this Act ; and

(*c*) exercise such other powers as may be necessary for carrying out the purposes of this Act.

6. The Local Government may appoint such qualified medical practitioners as it thinks fit to be certifying surgeons for the purposes of this Act.

7. (1) A certifying surgeon shall, at the request of any person desirous of being employed in a factory or of the parent or guardian of such person, or of the manager of the factory in which such person desires to be employed, examine such person and grant him a certificate in the prescribed form, stating his age, as nearly as it can be ascertained from such examination, and whether he is fit for employment in a factory.

(2) A certifying surgeon may revoke any certificate granted to a child under sub-section (1) if, in his opinion, the child is no longer fit for employment in a factory.

HEALTH AND SAFETY

9. The following provisions shall apply to every factory :—

(*a*) it shall be kept clean, and free from effluvia arising from any drain, privy or other nuisance ;

(*b*) it shall not be so overcrowded while work is carried on therein as to be dangerous or injurious to the health of the persons employed therein ;

(*c*) it shall be ventilated in such a manner as to render harmless, as far as practicable, any gases, vapours, dust or other impurities generated in the course of the work carried on therein that may be injurious to health ;

(*d*) the atmosphere shall not be rendered so humid by artificial means as to be injurious to the health of the persons employed therein.

11. (1) Every factory shall be sufficiently lighted.

(2) In the case of any factory which is not in the opinion of the inspector so lighted, the inspector may serve on the manager of the factory an order in writing, specifying the measures which he considers necessary for the attainment of a sufficient standard of lighting, and requiring him to carry them out before a specified date.

12. (1) In any factory in which humidity of the atmosphere is produced by artificial means, the water used for the purpose of producing humidity shall be taken either from a public supply of drinking water or from some other source of water ordinarily used for drinking, or shall be effectively purified before being used for the purpose of producing humidity.

13. Every factory shall be provided with sufficient and suitable latrine accommodation, and if the Local Government so requires, with separate urinal accommodation for the persons employed in the factory.

14. In every factory there shall be maintained a sufficient and suitable supply of water fit for drinking.

16. (1) Every factory shall be provided with such means of escape in case of fire for the persons employed therein as can reasonably be required in the circumstances of each case.

17. No person shall smoke, or use a naked light or cause or permit any such light to be used, in the immediate vicinity of any inflammable material in any factory.

19. No woman or child shall be allowed to clean any part of the mill-gearing or machinery of a factory while the same is in motion by the action

of steam, water or other mechanical power or electrical power, as the case may be, or to work between the fixed and traversing parts of any self-acting machine while such machine is in motion by the action of any power above described.

19A. Where, in the opinion of the inspector, the presence in any factory or any part thereof of children, who, by reason of their age, cannot, under the provisions of this Act, be lawfully employed therein, involves danger to, or injury to the health of, such children he may serve on the manager of such factory an order in writing, prohibiting the admission of such children to the factory or part thereof.

19B No person under the age of eighteen years and no woman shall be employed in any factory in any of the operations specified in Part I of the Schedule, or, save in accordance with the regulations contained in Part II of the Schedule, in any operation involving the use of lead compounds.

20. No woman or child shall be employed in the part of a factory for pressing cotton in which a cotton-opener is at work.

Hours of Employment and Holidays

21 (1) In every factory there shall be fixed,—

(*a*) for each person employed on each working day—

(*i*) at intervals not exceeding six hours, periods of rest of not less than one hour, or

(*ii*) at the request of the employees concerned, periods of rest of not less than half an hour each so arranged that, for each period of six hours work done, there shall be period of rest of not less than one hour's duration in all, and that no person shall work for more than five hours continuously, and

(*b*) for each child working more than five and a half hours in any day a period of rest of not less than half an hour.

22. (1) No person shall be employed in any factory on a Sunday, unless—

(*a*) he has had, or will have, a holiday for a whole day on one of the three days immediately preceding or succeeding the Sunday.

23. With respect to the employment of children in factories the following provisions shall apply :—

(*a*) no child shall be employed in any factory unless he is in possession of a certificate granted under section 7 or section 8 showing that he is not less than twelve years of age and is fit for employment in a factory and while at work carries either the certificate itself or a token giving reference to such certificate :

(*b*) no child shall be employed in any factory before half-past five o'clock in the morning or after seven o'clock in the evening :

(*c*) no child shall be employed in any factory for more than six hours in any one day.

24 With respect to the employment of women in factories the following provisions shall apply :—

(*a*) no woman shall be employed in any factory before half-past five o'clock in the morning or after seven o'clock in the evening ;

(*b*) no woman shall be employed in any factory for more than eleven hours in any one day.

27. No person shall be employed in a factory for more than sixty hours in any one week and for more than eleven hours in any one day.

MUNICIPAL REGULATIONS OF FACTORIES, TRADES, ETC.

Sec. 463. (1) No person shall, without the previous written permission of the Chairman, newly establish in any premises any factory, workshop, or workplace in which it is intended to employ steam, water or other mechanical power.

The Chairman may refuse to give such permission, if he is of opinion that the establishment of such factory, workshop or workplace in the proposed position would be objectionable by reason of the density of the population in the neighbourhood thereof, or would be a nuisance to the inhabitants of the neighbourhood.

TRADES NOT TO BE CARRIED ON WITHOUT A LICENSE

Sec. 466.—No person shall use or permit to be used any premises for any of the purposes herein below referred to or mentioned, without or otherwise than in conformity with the terms of a license granted by the Chairman in this behalf, for the following purposes: (*a*) Casting metals, manufacturing bricks, pottery or tiles; (*b*) as a knacker's yard, hide godown or hide-screw-house; (*c*) manufacturing or place of business from which offensive or unwholesome smells, fumes or dust arise; (*d*) as a depot for hay, straw, wood, coal, or rags; (*e*) packing, storing, pressing, cleansing, preparing, or manufacturing clothes in indigo or other colours, paper, pottery, silk; (*f*) storing, packing, pressing, cleansing or manufacturing any of the following:—blood, bones, candles, catgut, chemical preparations, China grass, cocoanut fibre, cotton or cotton refuse or seed, dammer, dynamite, fat, fins, fish, fireworks, flax, flour, gas, gun-cotton, gunpowder, horns, hoofs, hides, hemp, hair, iron, jute, leather, lime, manure, matches, meat, nitro-glycerin, offal, oil, oil-cloth, pitch, rags, rosin, salt petre, skins, soap, spirits, sulphur, soorkie, tallow, tar, turpentine, wool.

Sec. 472.—(1) No person engaged in any trade or manufacture specified above shall (*a*) wilfully cause or suffer to flow or be brought into any tank, reservoir, cistern, well, duct or other place for water belonging to the corporation or into any drain or pipe communicating therewith, any washing or other substance produced in the course of such trade or manufacture; or (*b*) wilfully do any act connected with any such trade or manufacture whereby the water in any such tank, reservoir, cistern, well, duct or other place for water is fouled or corrupted.

KEEPING OF ANIMALS AND DISPOSAL OF CARCASE

Sec. 453.—No person shall—

(*a*) Without the written permission of the Chairman or otherwise than in conformity with the terms of such permission, keep any swine in any part of Calcutta; (*b*) Keep any animal on his premises so as to be a nuisance or dangerous; or (*c*) feed any animal or suffer or permit any animal to be fed with or upon sewage or offensive matter.

CHAPTER V

SOIL

ALL soil may be considered as the result of the disintegration of rocks mingled with decayed vegetable and animal matter. It is usually divided into :—

(*a*) *Upper or surface soil,* which is chiefly the outcome of decayed animal or vegetable matter forming mould or "humus." The depth of this layer varies from a few inches to several feet.

(*b*) *Subsoil,* which results from the disintegration of the underlying primitive rock through the agencies of gases, water, etc. The depth of these layers also varies from a few feet to hundreds of feet.

SOIL FEATURES INFLUENCING CLIMATE AND HEALTH

Certain features of the soil influence the sanitary conditions of the inhabitants through the climate, the air, and the water. They are :—

A. **Conformation of the ground and its relation to the neighbourhood** as regards position and elevation. This depends on :—

1. The relative extent of hills and plains.
2. The height of the hills.
3. The direction of the main chains of the hills.
4. The angle of the main slopes of the hills.
5. The nature, size, and depth of the valleys.
6. The chief watersheds, and the direction and discharge of the water course, and
7. The amount of plain or flat land available.

Unhealthy spots among hills are closed valleys, and places, where there is stagnation of air, *e.g.* ravines. In the tropics ravines and *nullas* are usually unhealthy, as

they very often contain decayed vegetation, and a current of air may disseminate mosquitoes from such marshy places. A *saddle back* is usually a healthy site, and so are positions near the top of a slope. Places at the foot of the hills, especially in the tropics, are usually unhealthy, as they are damp and rich in organic matter on account of the accumulation of rain water and of the excessive growth of vegetable and animal life. Depressed or water-logged places are always damp.

B. **Soil Air.**—All the varieties of soil even the hardest rocks contain air in their interstices. Soil air differs from the atmospheric air. It is usually moist, and contains less oxygen which has been replaced by carbon dioxide resulting from decomposition of organic matter. The character of the ground air varies greatly depending mainly upon the character of the soil, the climate, the season and the rainfall. The amount of CO_2 in the ground air of a particular area will depend on

(*a*) quantity of organic matter,
(*b*) permeability,
(*c*) depth, and
(*d*) temperature and moisture.

If the ground air of two soils be examined, similar as regards organic impurities, temperature, and moisture, but of different permeability, the less permeable one will contain more CO_2. The amount of CO_2 also increases with the depth. This is due not to increased chemical action, nor to the presence of more impurities, but to the air not getting an easy vent as in the more superficial layers. Lewis and Cunningham, who investigated the ground air of the soil of Calcutta, found the amount of CO_2 at 3 ft. as follows :—

January	February	March	April	May	June
6.2	5.6	5.6	4.7	4.1	5.6
July	**August**	**September**	**October**	**November**	**December**
4.0	10.2	11.3	9.7	8.8	7.0

The results are stated in cubic centimeters per litre.

The sudden rise in August is coincident with high rainfall, and the fall in spring according to Lewis and

Cunningham is due not to diminished production but to increased loss of CO_2 in the atmosphere.

A continual interchange between the soil air and the atmospheric air is going on which keeps the soil air moving. This interchange is influenced by

(*a*) difference in the temperature of the air and soil,
(*b*) the ground temperature,
(*c*) rainfall,
(*d*) barometric pressure, and
(*e*) movements of the ground water.

Soil air may occasionally be contaminated with poisonous gases derived from defective drains, cesspools, or made soil, and may be aspirated into a house. This is of great practical importance from a sanitary point of view, and can be prevented by making the floors impervious by cementing or asphalting, or building the floor on arches. Instances are on record where coal-gas from leaky pipes has been known to find its way into distant houses following the track of water or drain pipes and thereby producing poisoning or explosion.

C. **Ground Water.**—The water present in the soil is divided into *moisture* and *subsoil* or *ground water*. When there is air as well as moisture the soil is merely moist and damp, but when all the interstices are completely filled with water, to the exclusion of air, there is a continuous sheet of water. The presence of moisture in the soil is the cause of decomposition of animal or vegetable matter which may exist in the ground. Damp soil is as a rule unhealthy. It may be produced by irrigation or by obstruction to drainage. The moisture of the soil is derived from :—

(*a*) rain,
(*b*) the rise and fall of the ground water, and
(*c*) evaporation of subsoil water.

The absorbability of moisture varies with the soil, open gravel absorbs least (about 10 per cent.) while sandy or peaty soils absorb most (60 to 80 per cent.). Some soils, *e.g.* hard limestone or dense clay, are practically impermeable to water, while others such as chalk, sand, and vegetable clay are permeable.

The Ground or Subsoil Water.—The depth of the subterranean water in any soil varies, sometimes it is 2 to 3 ft. from the surface, and in other cases as many hundreds. Probably the depth to which the water descends varies indefinitely according to the nature of the soil. The water which sinks into the soil is not permanently removed from the surface, but accumulates underneath till by the pressure of the descending column it is forced towards its natural outlets, in springs, rivers, etc.

The level of the ground water is constantly changing and the height of water in a well may be taken as an indication of the height of the subsoil water. It is liable to rise or fall according as the seasons are wet or dry. In some places it lies just near and in others far below the surface. When it is near the surface the ground above is always damp.

The ground water is constantly moving, flowing towards the nearest watercourse, a river or a sea. The rate of the movement varies, and is influenced by the ease or difficulty of the flow, relative density of the soil, and presence or absence of vegetation. The flow of water is also severely hampered by the interference of trees, roots, and smaller plants. In India the changes in the level of the subsoil water are very great. At Jubbulpur it is from 2 ft. to 12 or 15 ft. from the surface, at Calcutta from 5 to 15 ft., in Bengal it is generally from 2 or 3 ft. to 10 or 12 ft. from the surface. To render the soil drier it is necessary either to drain the soil by laying porous drains 10 to 12 ft. apart at a depth of 8 to 12 ft., or to open the natural outflow.

D. **Temperature of the Soil.**—This varies very much with its geological formation and the temperature of the air. The daily fluctuations in the temperature of the air do not influence the soil beyond a depth of about 3 ft., while a depth of about 40 ft. is affected by annual variations of temperature. The observations made in the Punjab showed that at 20 ft. the annual maximum was reached in September, while the minimum was in March. The temperature of the earth increases with the depth. The rate of increase in England has been estimated to be

about 1° F. for every 50 ft. As soils conduct heat in varying degrees, the absorptive power varies as well. Green vegetation lessens the absorptive power of the soil as evaporation occurs incessantly from the herbage. Damp soils are colder than dry ones, as the evaporation is constant. The temperature of the soil is taken at a depth of 4 ft.

E. **Soil Bacteria.**—Garden soil and agricultural humus contain a large number of micro-organisms. They usually find in the soil all the conditions necessary for their growth and multiplication. Nutrition is derived from decomposition of organic matter, moisture, air, and suitable temperature. These conditions are found more in the superficial than in the deeper layers of the soil.

One of the most important functions of the soil is the disposal and utilisation of organic matter. This is a complex process by which the proteins of the organic matter, animal and vegetable, are reduced to more simple and stable inorganic compounds. This disintegration is purely a bacterial action. Along with this process of catabolism there is also another phase of anabolism or building up process done by the living plants. These two processes—catabolism or breaking down and anabolism or synthesis—form the 'nitrogen cycle' and occur in the superficial layer of the soil. This nitrogen cycle, which goes on in the soil through the agency of soil bacteria and plants, has an important bearing in the purification of water, prevention of soil pollution and disposal of sewage. Thus, when an animal or plant dies the protein constituents are acted upon by the putrefactive organisms chiefly *B. subtilis* and *B. proteus*, and some bacilli of the colon group. These break up the nitrogenous matter into simpler products and a process of putrefaction and liquefaction takes place, when most of the bacteria pathogenic to man die. This putrefactive process goes on in the soil as long as the conditions for bacterial growth are favourable, viz. a suitable temperature, moisture and air. The breaking down of vegetable matter is however a slower process than the animal matter since the former contains less water and a smaller per-

centage of putrescible protein. The protien molecules are broken down by a process of hydrolysis into simpler amino compounds, the final products amongst other substances being carbon dioxide and ammonia. Part of the former passes into the atmosphere and the rest is retained in the soil as carbonates. Since ammonia as such cannot be utilised by the plants some of it also passes into the air and the rest remains in the soil as a chloride or carbonate. The ammonia is oxidised by the nitrifying organisms in the soil into nitrates which are stable and represent the final stage of mineralisation. The nitrates are held in solution in the ground water and are either taken up by the plants or are washed away in the ground water. The presence of nitrate therefore in the water is of some significance. (See Chemical Examination of Water pp. 45).

Varieties of Soil

Newsholme classifies soils as under :—

1. **Granitic, Metamorphic,** and **Trap Rocks** owing to the good drainage and slope are always dry and form healthy sites for houses. "Weathered" granite, however, is an exception to the rule, as it becomes disintegrated and softened, absorbs water, and becomes permeated with lower forms of organisms.

2. **Clay Slate** is equally healthy, the water-supply and vegetation being less.

3. **Chalk,** when free from clay, is always a healthy soil, but with clay, *i.e.* marly, it is damp and cold.

4. **Limestone,** and **Magnesian Limestone Rocks** have considerable slopes, so that water runs off quickly. The hard oolite is the best and magnesian the worst.

5. **The Sandstones.**—Here both the soil and air are dry, and therefore, healthy. If the sand be mixed with clay or if clay lie under a shallow layer of sand rock, the site is sometimes damp and cold. The hard millstone grit formations are healthy.

6. **Gravels,** unless water-logged, are healthy in any depth. Gravelly elevations are the healthiest of all sites, and the water-supply is usually pure.

7. **Sands.**—When of considerable depth and free from organic matter these may be considered healthy, but when they are shallow and lie on a clay basis, or when the subsoil water rises through them to a high level, they are unhealthy. They are equally unhealthy when water is found within a yard of the surface or when they contain soluble mineral matters. In the Punjab sand contains lime, magnesium, and salts of alkaline earth.

8. **Clay, Dense Marls,** and **Alluvial Soils,** owing to the retention of water in them, are cold and damp. A clay soil will improve by thorough drainage. Alluvial characters are to be seen in the deltas of big rivers.

9. **Cultivated Soils.**—Well-cultivated soils are frequently healthy. Irrigated lands favour the breeding of mosquitoes, therefore dwelling-houses should not be constructed in the vicinity of such places.

10. **Made Soil.**—When tanks, hollows, or other depressions of the ground are filled up with refuse the resulting site is called *made soil.* The chief point to be considered in such cases is whether the local conditions are favourable for rapid disintegration of organic matter. The complex organic substances are disposed of by the nitrifying micro-organisms and are converted into harmless inorganic compounds which are finally removed by percolating rain water. Insanitary tanks or low-lying lands where water can accumulate should be filled up for improving the local sanitary conditions, but to carry this out effectively and without offence certain precautions are necessary. The refuse undergoes fermentation and putrefaction with the formation of certain gases, chiefly marsh gas, sulphuretted hydrogen, etc., which may travel a long distance underneath the ground. The serious nuisance and consequent ill-health can be avoided by attending to the following points :—

(i) All such sites should be dry, and in case of tanks or land subject to flooding the water must first be drained away and arrangements made to protect such areas by embankment.

(ii) The daily deposit of refuse should be covered over by a layer of dry, clean earth about 6 in. deep. This

prevents the refuse from being blown about by wind, and emanation of foul vapours and breeding of flies.

(iii) Whenever practicable such works should be completed before the onset of the rains to prevent formation of offensive puddles and breeding of flies.

(iv) Large tanks should be partitioned either by means of bamboo matting or earthen dams, and each part taken in turn. The process should begin at one end and then gradually advanced onwards.

(v) The land should not be used for some years (ten to twenty or even more according to the nature of the materials dumped) for building purposes, and should only be utilised for gardening or cultivation, care being taken to drain it properly.

(vi) No dead animals, slaughter-house garbage or fæcal matter should be thrown into the hollow.

(vii) The hollows should be raised about 2 ft. above the surrounding area to make an allowance for settlement.

Dampness of Soil.—Damp soil is, as a rule, unhealthy, and, when permanently wet, it generally contains much organic matter. To render the soil fit for habitation proper drainage for readily carrying away surface or storm water without permitting it to percolate into the soil and land should be made. Wherever necessary subsoil drains should also be constructed to permanently lower the level of the underground water.

According to Simpson the following are the causes of dampness :—

1. *Retentive Soils.*—Clay soil is difficult to drain and when the land is low-lying, swamps are easily formed which add to the unhealthiness of the locality. Alluvial soils when mixed with clay, sand, and a large proportion of organic matter, as met within valleys or in low-lying lands, are also unhealthy.

2. *Impermeable Layer near Surface.*—The depth of the subsoil water should be at least 5 ft. from the surface. When the impermeable stratum is too close to the surface it holds up the soil water very near to it.

3. *Obstructed Drainage.*—Obstruction to the flow of the underground water or natural drainage of the locality

brought about by embankments often gives rise to dampness and marshiness. That railways are responsible for the spread of malaria in certain districts may be best explained in the words of Professor Simpson : " Wherever railways do not follow the watershed of the district ample provision should be made to secure diversion and sufficient outlet for the drainage which is likely to be obstructed. In all new railways in the tropics this essential factor in the health of the localities through which the railways pass should be insisted on."

4. *Burrow Pits.*—When excavations are converted into stagnant pools and marshes they become breeding-places for mosquitoes. Such excavations are generally made on either side of the railway for raising the embankment. In all such cases arrangements should be made to empty these into the nearest watercourse.

5. *Sand Pits and Clay Pits.*—These are generally formed when earth is required for building purposes, and are very difficult to drain and add to the unhealthiness of the place.

6. *Silting up of Streams.*— This leads to the obstruction of the natural drainage and makes the place unhealthy and malarious. For example may be mentioned the silting up of the water ways in different parts of Bengal.

7. *Neglect to Keep Clear Water-ways.*

8. *Introduction of Water-supply without Provision of Drains.*

Effect of Irrigation on Soil.—Irrigation makes a healthy locality unhealthy when not attended with efficient drainage. When a large volume of water is allowed to run into a district the natural outlets, which may have been sufficient for its drainage prove inefficient, making the soil damp and water-logged.

For the proper management of irrigition works in India without affecting the health of the district the following rules are to be observed :—

1. The irrigation canals to be constructed along the line of the watershed.

2. The smaller canals should be so constructed as not to be carried across the natural line of drainage.

3. Drainage cuts to be constructed along the natural line of outfall.

4. The supply of water should be limited to the amount required, and to the particular time needed to secure the success of the crops.

Diseases Arising from the Soil

The upper few inches of the soil contains innumerable number of bacteria which give to the soil a sticky moist feeling so common with rich living soils. Very few bacteria are however found below the depth of 4 to 6 ft. in an undisturbed soil. Houston found on an average 100,000 per gramme in an uncultivated sandy soil, and 115,000,000 per gramme in a sewage soil, bacteria which ordinarily grow in the usual laboratory media. The bacteria are either *saprophytic* or *pathogenic*, but the former are found in abundance. Pathogenic bacteria do not as a rule find a suitable medium in the soil for growth and development. Thus, Koch has shewn that anthrax and other pathogenic micro-organisms may grow on sterile soil but not in soil with ordinary soil-bacteria, *i.e.*, in living soil. These die in the struggle for existence. The soil however contains certain bacteria or their spores, *e.g.* of malignant œdema, tetanus, etc.

Usually the soil is capable of disposing of organic matters. Without this property the earth surface would have long become clogged with these substances. But sometimes it is unable to carry out this process, specially when overloaded. Under these conditions the soil remains polluted.

The soil was held responsible for the spread of certain infectious diseases, notably typhoid and tuberculosis. Few pathogenic organisms however can actually live in the soil. But a soil polluted with human excreta may contain specific organisms and give rise to different types of intestinal troubles. Thus cholera, amœbic dysentery, typhoid, etc., may all be produced from infected or polluted soil, though indirectly, through water, dust, or flies. Certain vegetables eaten raw may com-

municate eggs of worms and bacteria in a mechanical way when grown on polluted soil. Finally, all water for drinking or otherwise must have passed through soil which materially affects its character. Infection contracted directly from soil polluted with human excreta is chiefly hookworm, and the eradication of the disease depends primarily upon the prevention of soil pollution. Again, tapeworm and other intestinal parasites pass part of their life cycle on or in the soil.

Anth ax.—Under normal conditions anthrax does not grow and multiply in the soil, although spores have been found in fields where infected animals have been allowed to graze. Pasteur demonstrated the presence of the bacillus in the soil and believed that the spores were brought to the surface by earth worms. Recent researches however seem to show that the danger of infection from the soil is unimportant and anthrax rarely occurs through soil infection.

Enteric Fever.—Pettenkofer considers that the variations of the level of the ground water in an urban area are associated with the rise and fall of the typhoid death-rate. He considers that outbreaks of enteric fever occur when the subsoil water is at its lowest. Enteric excreta when buried superficially in dry sandy soil may be carried about by air and infect food. It is hardly possible that the bacillus multiplies at all in the soil, as it rarely lives more than a month or two there. On the other hand there are many possibilities of infection being conveyed through soil once it is polluted by typhoid excreta. Thus, the drinking water may be infected, or the bacilli may be carried about mechanically by the agency of flies, dirt and dust.

Cholera.—Pettenkofer holds a similar view with regard to cholera. He considers that epidemics occur when the soil is porous, and has been rendered moist by a rise of subsoil water, which allows the air to penetrate the soil during the fall of ground water with which the cholera bacilli find their way. In India epidemics occur either during or after the rains which wash the bacilli from the surface of the soil into wells, tanks and other sources of

water supply. Under normal conditions the bacilli die quickly when deposited upon or in the soil. It is possible that when the soil is infected with the excreta of cholera patients the vibrios may be carried by dirt, flies and dust. Cholera is rarely contracted directly from the soil.

In India the evidence is in favour of the soil being a medium for the propagation of the disease in which the bacilli retain their vitality for a long time.

Diarrhœa (epidemic or summer).—This is associated with low-lying alluvial soil. The soil temperature at a depth of 4 ft. is important and the summer rise in the temperature rises over 56° F. The annual recurrence of diarrhœal affections, especially among infants, is due to the rise of temperature of the soil and consequent resuscitation to activity of certain pathogenic saprophytes to which these diseases are due, and to the changes effected by their means in milk and other food.

Animal Parasites.—It is well-known that *ankylostomum duodenale* is associated with soil infection, especially moist sandy soil. Similarly most of the intestinal parasites of man are deposited on the soil and re-infect man during one of the stages of their life cycle.

Phthisis.—The effects of damp soil in the prevalence of phthisis, though indisputable, is only indirect. Combined with cold wind, chill and moisture it might induce respiratory catarrh and thus render persons more susceptible to the attack of tuberculosis, especially if the domestic and other conditions be insanitary.

Tetanus.—The normal habitat of tetanus bacillus is the intestines of herbivora. The spores commonly occur in the soil of inhabited regions and have been found not only on the superficial soil but at times a few feet under the soil. The bacillus probably does not grow in the soil and although it can live in other places besides soil, yet soil is the chief medium through which the germs are distributed.

Malignant Œdema.—The bacillus is found in the superficial layers of the soil and is found with putrefying matter.

CHAPTER VI

HOUSES AND BUILDINGS

THE selection of the site for building purposes is often done without any regard to its suitability from a sanitary point of view. The primary consideration in the selection of a building site should be dryness, warmth, light and air. The following points therefore require careful consideration :—

1. Since dryness of the soil is dependent upon the facility with which rain water can pass off, the ground selected must be rising with a sufficient slope to allow the rain water to be drained off rapidly.

2. Permeability of the soil should not be overlooked. The soil should be of a loose gravelly nature to allow free drainage. The worst soils are shallow beds of gravel or sand lying over clay, as also alluvial tracts, owing to their frequent water-logged condition. *Made soil* should, as a rule, be avoided for building purposes.

3. The building should be open on the east and south, and a part of it atleast should be exposed to the sun.

4. Vegetation around the house will keep it cool, but if it be too close it may make the house damp by obstructing light and air.

5. The site should be at a distance from marshes, paddy fields, cowsheds, stables, etc.

6. The surface soil or subsoil should not be polluted by sewage or other refuse, and the surface drainage of the soil must be good.

7. Vicinity of a bazaar or a *bustee* should be avoided. Similarly, places close to trenching grounds, open lands where refuse is thrown, factories, etc., are unsuitable for building purposes. Servant's quarters should be as far away as possible, especially in malarious places.

8. A site with a constant level of subsoil water is better than a place where the subsoil level varies in different seasons of the year. The ground water should be about 6 ft. below the surface and not subject to sudden changes.

Construction of Houses

To make a house healthy it must be properly lighted and ventilated and made dry, as a damp building harbours disease. Dampness may originate from the soil on which the house stands, or from rain, leaky roofs, or from planting trees too near to the house. Bricks by their capillary attraction draw up moisture from the soil and make a house damp. Ill-ventilated and closed houses without a sufficient number of doors and windows for admitting light and air are always damp. It is almost impossible in India to adequately ventilate a room by natural means unless arrangements are made for cross ventilation by means of doors and windows. Situated in narrow lanes as most of the houses in congested parts of towns are, with a narrow frontage, and wedged in between adjoining buildings, three out of four blocks are absolutely shut in save for the tiny courtyard which in lofty buildings is almost well-like. The Oriental style of constructing buildings with an open central court has the advantage of admitting light and air into the interior of each room, provided the area of the courtyard is in proportion to the height of the structures around.

The whole of the lower storey of the *zenana*, even in large and valuable houses, is generally used as godowns and kitchens. The average kitchen is a gloomy, stuffy den, full of acrid smoke, and the absence of chimneys results in an atmosphere which is almost unbearable when cooking is going on in a particularly ill-ventilated kitchen.

The system of dividing dwelling-houses amongst several co-heirs is a potent factor in the production of insanitary property. Each co-sharer erects as lofty a masonry wall as he possibly can, so as to shut off completely his share from the rest. The result too frequently

is that a noble mansion with spacious courtyards is converted into a number of mean little houses with totally inadequate open spaces, and most of the rooms imperfectly lighted and ventilated.

The Foundation must always be solid and substantial. When the soil is soft and yielding, the walls should be broad and built on a solid basis of concrete. In making the foundation the ground should be dug up, and then a bed of good cement concrete made covering the whole site of the house and extending 6 in. beyond the "footings" of the walls on every side. The object of laying this bed of concrete is to prevent subsidence which occurs in buildings erected on loose soils or without a good concrete. The depth of this concrete should depend upon the weight of the wall which has to be supported and in no case should be less than 18 inches. In addition to this bed of concrete a layer of impervious material known as the "damp-proof course," should be laid horizontally for the entire thickness of each wall, above the point where the wall leaves the earth, but below the level of the floor. This precaution is taken to impose a barrier to the upward progress of the moisture. By capillary attraction the bricks absorb moisture from the soil even as far as the upper rooms and makes the house damp and unhealthy. The materials used for this purpose must be impermeable to moisture and sufficiently strong to stand the superincumbent weight and unequal pressure, and may consist of one of the following :—

1. Sheet lead,
2. Two layers of roofing slate,
3. A layer of good asphalt 2 in. thick,
4. Well-tarred bricks, and
5. Patent stone made with stone chips, cement and stone dust of 1 inch thick.

Efficient ventilation with dryness of the floor may be ensured by erecting the house on arches; but care should be taken to keep the ground surface perfectly clean and dry, for, not infrequently, this is allowed to remain wet and filthy, and becomes a receptacle for dirty water, refuse, etc.

Walls.—The materials usually employed for the construction of the walls of dwelling houses are bricks, stones, or wood. A good brick should be well burnt, of a regular shape, of a uniform colour, and when struck should give a clear metallic sound. Ordinary bricks are porous and so allow air and moisture to pass through them. The brickwork of the wall should be at least 15 in. thick; the thickness is usually regulated by consideration of stability. The bricks should be properly bound together by being laid length ways and cross ways alternately. Wood, unless well seasoned, should not be employed. A thin-walled house is hot in summer and cold in winter. It is necessary that the outer walls above the ground level should be so constructed as not to admit damp even if exposed to rain and wind. Hollow external walls would resist any amount of damp, and they consist of parallel walls separated by an air space of about 2 in. and tied together by binding ties of iron; but the constant presence of rats, etc., within double walls makes it difficult to prevent a nuisance arising therefrom. A good plan therefore is to fill the space between two such walls with asphalt, thus forming a vertical damp-proof course.

The *chimney flues*, where necessary, should be properly constructed during the erection of the house walls. They should be circular, straight, and higher than the surrounding building, and not made of any inflammable material.

The walls of houses are mostly plastered and white or colour-washed outside. The plaster is chiefly a mixture of *chunam* (lime) and river sand. It has been the custom of late to leave the outside walls with bricks exposed, but for this, neat work with good bricks is required. Although this looks well and refreshing to the eye, it makes the buildings proportionately hotter.

The inside of walls is generally covered with plaster. Ordinarily this consists of two layers, the first is a mixture of lime and sand, and the second of slaked lime mixed with water to the consistency of cream. The treatment of this surface of the room however differs; it may be:—

(*a*) *Limewashed* with quicklime and water. This acts as a germicide.

(*b*) *Whitewashed* with a mixture of whiting or finely-ground chalk and water. Some alum or gum may be added to protect it from being rubbed off.

Oil painting is also done. This renders the surface impervious and enables it to be easily washed. The painting of wood and iron work with oil paints is valuable not only as a preservative but also because it prevents absorption of organic matters.

Papering is rather rare in India, being rapidly deteriorated by the climatic conditions that prevail.

The upper floors may be made of wood, or terraced and cemented. *Floors* are best made of impervious materials which can be washed. Bricks, stones, tiles, broken bricks and mortar, cement, asphalt, etc., are all used in India. The floor of the ground storey should invariably be air and water-tight. The concreted floors are usually covered with a layer of good cement, patent stone or marble slabs.

The roofs of Indian houses are either flat or terraced, sloping or pent. Flat roofs should have just enough slope to allow rain-water to flow off. Roofs should always be high, as the heat radiated from a roof is in inverse ratio to the square of its distance. Flat roofs are not so cool as sloping ones and are not so well adapted for ventilation. They, however, afford a promenade and a place for sleeping in the hot weather.

Sloping or *pent roofs* may be either of tiles, slates, thatch, corrugated iron, etc. Tiled roofs are coming more into fashion with the introduction of different varieties of tiles. Thatched roofs made of hay or straw, spread on a bamboo frame-work, and about 6 to 12 in. thick, are often used for the construction of bungalows, especially in those parts of India where the heat is great. These are very cool and dry, but their liability to take fire easily and the shelter they give to rats, insects, and other animals are the great drawbacks. This may partly be obviated by occasional renewals. A double tiled roof with a space between should make a very cool-covering to a dwelling. Corrugated or galvanised iron is also used as

roof covering. This is very hot in summer and noisy during the rains, but is very well suited for hill stations.

The height of the rooms should be at least 10 ft., and every room must have at least one window opening to the outer air direct. But very great height is not desirable unless proper arrangements are made for the exit of foul and warm air from the upper part of the room.

The *kitchen* should not be near a privy, or so placed as to allow the smoke and smell of cooking getting into the rest of the house. It should not be on the side of a busy road and thus be exposed at all times to the dust and the impurities it contains. It must be fly-proof with automatic closing doors with openings for the exit of the smoke as near the ceiling as possible. It should have floors with impervious materials, *e.g.* cement concrete or brick on edge, and have proper arrangement for washing. The garbage should be collected in a special covered receptacle which should be emptied at regular hours at least twice a day.

Water-closets or *privies* should be confined to one part of the house. At least two sides, if not more, should be open to the outside air, and the floor and walls up to a certain height should be of cement or glazed tiles. In villages where more land is available the privy should always be at a distance from the main building.

Disposal of Rain and Slop Water.—Every house should be provided with rain-pipes for getting rid of rain water. These may be either of wrought iron, tin, or earthenware. Those made up of wrought iron are the best. Houses with sloping roofs should have gutters all round the lower edge of the roof to catch the rain, with openings at intervals, whence the water is carried down by ordinary rain-pipes. In order to prevent surface water percolating into the ground and thus making the house damp the surrounding area should be cemented and the water carried either direct into a yard gully or sewer, or into the main street drain through half-channelled open surface drains.

The Housing Problem

Nowadays, in cities like Calcutta and Bombay, various new problems relating to the construction of dwellings for proper accommodation are being seriously discussed ; the chief point to consider being how to obtain an abundant supply of air and light. To meet these ends, well-built, well-drained, and healthy *residential quarters* or *lodging houses* are constructed.

A. **Residential Quarters.**—The following points should be attended to in the construction of a residential flat :—

1. The building, the drainage, and the water-supply should conform to the Municipal Act.

2. The staircase, flats, and pantry should be well lighted and aired.

3. The water-closet for each flat should be in a detached portion of the building, and the number should be in the proportion of one for every six persons.

4. There should be abundance of water-supply and proper arrangements for efficient drainage.

5. Each block or flat should be complete with separate water-closets, baths, kitchen, etc.

6. There should be sufficient open space for each block or flat.

7. The kitchen should also be detached, to prevent smoke from entering into the residential quarters, and connected to the main building by a covered passage.

8. The servants' quarters should be away from the house but within the compound.

B. **Lodging House :**—

By a " lodging house " is meant a house where persons of the poorer class are received for short periods (usually at night), and although strangers to one another, are allowed to inhabit a common sleeping room. Such lodging houses (mostly unauthorised) exist in different parts of India, especially in places where people go for a pilgrimage and stay for a short time only.

The cubic space per head in a lodging house should not be less than 300 ft. The rooms must be properly lighted and ventilated, and arrangements made for regular and

thorough removal of refuse and slops. There should be a sufficient supply of good water.

Bustees and Huts

"**Bustee**" means an area containing land occupied by, or for the purposes of, any collection of huts.

Bustee Land means land in a "bustee" which is let out for the building of huts under an arrangement by which the tenant of the land is the owner of the hut.

Hut means any building no material portion of which above the plinth level is constructed of masonry.

The *floor* of such huts are commonly of earth without any damp-proof course or bed of concrete and consequently are very damp. Huts may also be floored either with split bamboos or with *jarool* planks. The plinth should be at least 2 ft. or 3 ft. high. This will keep the floors dry and properly drained.

The *walls* are either of wood, unburnt bricks, bamboo matting plastered over with mud, or corrugated iron or tin. The *roofs* are made either of thatch, paddy straw, *ooloo* grass, palm-leaves or country tiles (*khaprels*), or corrugated iron.

Such huts are very unhealthy, and efforts should be made to improve them. It is important that all huts should have an open space or courtyard to which each room should open. Each hut should be a detached structure and built in a continuous line with proper arrangements for light and ventilation. The huts should be of uniform height and not made higher than 16 ft. In the construction of huts the following points should be attended to :—

(*a*) The use of cowdung as a covering for the floor and wall should be stopped.

(*b*) Mud floors should be dug up and removed every few months : a layer of fresh mud must be laid again. It is better to have cement floors.

(*c*) Each room should have at least two windows 2 ft. square, opposite each other ; in the case of one window it should be 3 ft. square.

(*d*) Mud walls should be periodically whitewashed.

(*e*) Dirty water and waste food and garbage should not be thrown in the vicinity.

(*f*) The windows and doors should be left open morning and evening for free ventilation.

(*g*) The latrine must be outside the main hut and must have an impermeable floor, easily accessible from behind for the sweeper. It must be cleaned daily and have the door and window large enough to allow plenty of fresh air and light.

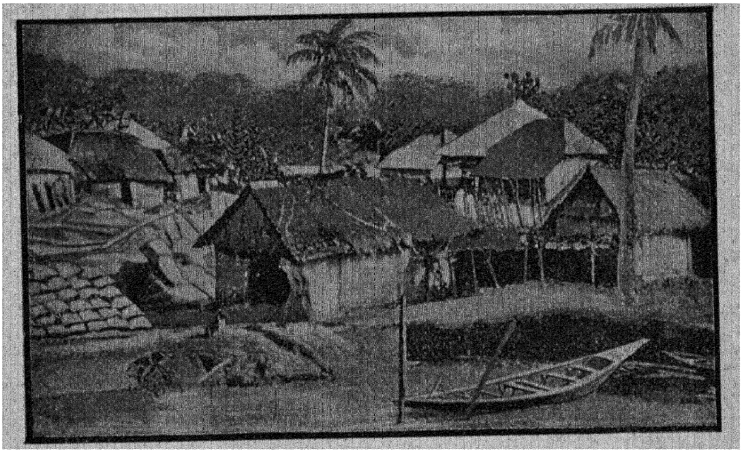


FIG. 9.—A Group of Huts.

In this country one of the greatest difficulties in the way of civic improvement is the irregularity with which the huts are erected in *bùstees* without any provision of decent passages for scavenging and efficient drainage. The evils attendant upon overcrowding and the aggregation of large number of peoples in these *bustees* or *mahalas* are disease, danger, and filth. Such an arrangement contributes largely to the insanitary condition of the localities from imperfect ventilation and the impossibility of carrying out proper scavenging. Figure 9 shows a group of huts, the insanitary condition of which is ob-

vious. The roads should, as far as possible, run in parallel lines and the cross roads should intersect others at right angles. The huts should be 6 ft. apart from wall to wall and 3 ft. from eave to eave ; and between each row there should be a passage of 9 ft. while the main road should be 16 ft. wide with side surface drains. Dust-bins should be placed at convenient distances, and latrine arrangements made according to the demand of the population.

Bakehouses

In India it is rather exceptional to find a bakehouse built on sanitary principles. The law relating to them being very defective, any room or hut may be converted into a bakehouse. The sanitary principles for the construction of a house where food is prepared must be rigidly enforced. A very common defect is that the floors are not made impervious ; such floors are productive of serious nuisance as they do not admit of proper cleaning. It is best to have the floors paved or cemented. The rooms should be well lighted and ventilated, and the walls, etc., should be lime-washed at least every six months, and no part of the room should be used for sleeping purposes. No water-closet, privy, or sewer should communicate with the interior of a bakehouse, nor should any animal be kept there.

Cowsheds and Stables

They must be separate structures and placed at a distance of about 20 ft. from any place of human habitation, and at a distance of at least 50 ft. from any source of water-supply. Cowsheds and stables should always be well lighted and well ventilated with floor raised about 6 in. above the surrounding ground level. The floor should have a slope on one side, and must be of some impermeable material, either brick-on-edge with cement pointing, or stone paved. These should have a good roof to keep out sun and rain, and walls to prevent the damp and cold winds blowing on the cattle. The drains should be plastered with cement and should lead either into a

vat or a movable and non-absorbent receptacle of sufficient size, protected from flood and rain. The vat should be at a distance of about 10 ft. outside the stable wall.

Each cow must have a clear space of 8 ft. × 4 ft. and a minimum air space of 600 cubic ft., each horse 9 ft. × 5 ft. and each buffalo 8 ft. × 5 ft. The best form of cowshed is an open one, protected only by a roof and low walls. Every cowshed, stable or cattle shed should be thoroughly cleansed twice a day, and should have a good water-supply. A sufficient number of dustbins must be provided, and arrangements made for regular removal of refuse.

Dairies.—No milk store or milk shop should be used as a sleeping apartment or for any other purpose likely to contaminate milk, which has the remarkable power of absorbing gases, and so of deteriorating in quality within a very short time. Proper provision should therefore be made for the protection of milk against infection. No dairy should communicate with privies or drains, and all milk cans should be steamed or scalded immediately after use. All dairies should be properly lighted and ventilated, and provision made for their cleansing, drainage, and water-supply.

RULES ON BUILDING SITES AND BUILDING WORKS

1. No piece of land shall be used as a site for the erection of a building :—

(1) if the building is to abut on a street, unless the site is of such a shape that the face of the building can be made parallel to the line of the street, or as nearly parallel to the said line as the General Committee may consider practicable :

(2) if the site is within thirty feet of tank, unless the owner satisfies the Engineer that he will take such order as will prevent any risk of the domestic drainage of the building passing into the tank ; and

(3) if the building to be erected is a public building, a dwelling house or a hut,—

- (*a*) unless the site is certified by the Engineer to be dry and well drained, and
- (*b*) if the site is a filled-up tank, or has been filled up with or used for depositing rubbish, offensive matter or sewage, unless the site was so filled up or last so used more than five years pre-

viously, and unless the Chairman has examined the site and granted a certificate to the effect that it is, from a sanitary point of view, fit to be built upon.

BUILDINGS GENERALLY

3. The floor or lowest floor of every building erected or re-erected from the ground-level must be constructed at such level as will admit of—

(a) the construction of a drain sufficient for the effectual drainage of the building and placed at such level as will admit of the drainage being led into some municipal sewer at the time existing or projected, and

(b) the provision of the requisite communication with some sewer into which the drainage may lawfully be discharged, at a point in the upper half of such sewer, or with some other means of drainage into which the drainage may lawfully be discharged.

7. (1) Except with the sanction of the General Committee, the foundation of a masonry building must rest on solid ground.

(2) The spread of the foundation must be such that the pressure on the soil shall not be greater than one ton on the sq. ft.

8. The plinth of a masonry building must be atleast 2 ft. above the level of the centre of the nearest street.

9. Every wall of a masonry building must be constructed so as to rest upon proper footings having regular offsets and a horizontal spread on each side of the wall of not less than one-half the height of the footings, unless an adjoining wall interferes, in which case the footings may be omitted.

10. The outer walls of a masonry building must be constructed of brick or some other hard and incombustible substance.

12. (1) Every wall of a masonry building must have a damp-proof course at or above the level of the ground floor.

(2) Such damp-proof course may consist of sheet lead, asphalt, slates lain in cement, vitrified bricks or any other durable material impervious to moisture.

19. The whole of at least one side of every room in a dwelling house must either be an external wall or abut on an interior court-yard or on a verandah.

20. Every room in a domestic building which is intended to be used as an inhabited room—

(a) must be in every part not less than ten feet in height, measured from the floor to the underside of the beam on which the roof rests;

(b) must have a clear superficial area of not less than eighty sq. ft.; and

(c) must be provided, for purpose of ventilation, with doors or windows opening directly into the external air, or into a verandah, and having an aggregate opening of not less than one-fifth of the superficial area of that side or one of those sides of the room which faces or face an open space.

21. (1) The minimum superficial area of every interior courtyard of a dwelling house shall be one-fourth of the aggregate floor area of the rooms.

(2) The minimum width of every such court-yard shall be eight feet.

26. No room other than a bath room or privy shall be placed over a privy in a domestic building.

HUTS

37. Huts in a bustee must be built in continuous lines, in accordance with an alignment to be prescribed by the General Committee and demarcated on the ground.

38. Where an alignment prescribed as above does not correspond with the alignment of a street in the bustee, a passage of at least twelve feet, measured from eave to eave, must be left between the rows of huts abutting on such prescribed alignment.

41. There must be between all huts abutting on a street in a bustee a space of at least three feet measured from eave to eave.

42. Except with the sanction of the General Committee, no hut shall be placed at a greater distance than one hundred feet from the nearest part of a metalled and sewered street.

43. No portion of a hut shall be placed within six feet of a masonry building.

45. No hut shall comprise more than two stories or shall exceed eighteen feet in height, measured from the top of the plinth to the junction of the eaves and wall.

46. The plinth of a hut must be raised at least two feet above the level of the centre of the nearest street or passage.

STABLES, CATTLE-SHEDS AND COW-SHEDS

Sec. 455.—(1) The Corporation, at the instance of the General Committee, may give public notice of their intention to declare—

(a) that in any area specified in the notice no person shall keep milch-cattle for the purpose of supplying milk for sale, and

(b) that all milch-cattle kept in such area for such purpose must be removed from such area within a period, not being less than three weeks not more than six months, to be specified in such notice.

Sec. 456.—(1) All stables, cattle-sheds and cow-houses shall be under the survey and control of the General Committee as regards their site, construction, materials and dimensions.

(2) The General Committee may, by written notice, require that any stable, cattle-shed or cow-house be altered, paved, repaired, or kept in such a state as to admit of its being sufficiently cleansed, or be supplied with water or be connected with sewer, or be demolished.

(3) Every such notice shall be addressed to the owner of the building or land to which the stable, cattle-shed or cow-house belongs, or for the use of the occupants of which the same was constructed or is continued.

Sec. 457.—If any stable, cattle-shed or cow-house is not constructed or maintained in the manner prescribed by or under this Act, the General Committee may, by written notice, direct that the same shall no longer be used as a stable, cattle-shed or cow-house.

CHAPTER VII

FOOD

A FOOD may be defined as anything which, when taken into the body, is able either

(i) to build up or repair tissues, or

(ii) to supply material for the production of heat or muscular work.

A true food must therefore be either a tissue builder or a source of potential energy.

Certain articles, *e.g.* condiments, though strictly speaking they cannot be classed as food, are used as accessories and help in the assimilation of food. Considering the part it plays in the assimilation, salt may also be classed as an important food.

CLASSIFICATION OF FOODS

Foods are variously classified, depending upon their source, into those obtained from the organic kingdom, and those derived from the inorganic kingdom. The former class embraces proteins, fats, carbohydrates and organic acids ; while the latter includes mineral salts and water. All these substances are obtained in varying amounts from the animal and vegetable kingdom. Sometimes foods are classified as nitrogenous and non-nitrogenous foods depending upon the presence or absence of nitrogen. Milk contains all the proximate principles of diet and is an example of perfect food for growing children.

Strictly speaking condiments, tea, coffee, etc., are accessories to food. These and the various spices excite the digestive juices and produce a desire for food.

The statement that a diet consisting of the five well-known elements—proteins, fats, carbohydrates, salts, and water—is all that is necessary for the maintenance

of health requires some modification. It has been found that young rats fed on purified protein, carbohydrate, fat, salts, and water cease to grow even if the quantity supplied is correct. But if only a teaspoonful of fresh milk is given daily growth becomes normal. It appears, therefore, that in addition to the different proximate principles of food small amounts of other substances play an accessory or even an essential rôle in the complex chemical processes of nutrition. These substances have been named *vitamins*.

The nutritive constituents of food may be grouped thus :—

- Organic
  - Albuminous or Nitrogenous
    - Proteins
      - Myosin of meat.
      - Casein of milk.
      - Gluten, Legumin.
    - Albuminoids
      - Gelatin.
      - Chondrin.
  - Non-nitrogenous
    - Carbohydrate
      - Starch.
      - Sugar.
    - Fats or hydro-carbons
      - Oils.
      - Fats, Butter.
      - Ghee, etc.
    - Vegetable acids
      - Oxalic,
      - Citric, etc.
- Inorganic
  - Water
  - Mineral matter or Salts
    - Common salt.
    - Chlorides.
    - Phosphates.
    - Lactates, etc.

Proteins.—These are complex bodies colloid in character excepting in certain leguminous plants where they are crystalline. They are found both in animal and vegetable food and are most essential for the maintenance of animal life. They are also known as *nitrogenous* or *flesh forming* substances and are composed of—

Nitrogen	..	16 per cent.	Hydrogen		7 per cent.
Carbon	..	54 ,,	Sulphur	..	1 ,,
Oxygen	..	22 ,,			

The animal proteins are more easily digested than vegetable proteins. But the primary sources of proteins are from the flesh of animals, eggs, milk and certain seeds and fruits of plants, especially of the leguminous order.

The functions of the proteins are :—

(i) They contribute to the formation and repair of the tissues.

(ii) They form the digestive and other fluids of the body.

(iii) They regulate the absorption and utilisation of oxygen, and play an important part in the chemistry of nutrition.

(iv) Under certain conditions they form fat, as the fat of milk is derived principally from the protein of the food.

(v) Under certain conditions proteins supply energy and heat, and may take the place of carbonaceous foods.

Fats or Hydrocarbons.—These are compounds of fatty acids, *e.g.* palmitic, stearic, etc., with glycerine. They are composed of carbon, hydrogen, and oxygen, the amount of oxygen is insufficient to combine with hydrogen to form water.

One of the great purposes served by fat in the food is to diminish albuminous metabolism, and therefore it is called "albumin sparing food." If flesh alone be given large quantities are required in order that nutrition and waste may balance each other, but if fat be added the demand for flesh is diminished. Fats, however, have an important relation in the body to the production of force and heat, and also to bodily work and bodily temperature. They yield about $2\frac{1}{4}$ times as much energy as an equal amount of carbohydrates. Unlike proteins the metabolism of hydrocarbons is independent of the amount of food taken, but is affected by bodily exercise which produces little effect on nitrogenous metabolism. In some cases fat is eaten in excess. In temperate climates an excess of fat is usual in the diet of those who do hard work, where the fat is more or less directly utilised as a source of energy. But when there is excess of fat in the diet of sedentary persons, part of it is unabsorbed and

passes out with the fæces, but a large amount is stored up in the body. Every body knows that fat animals stand privation of food better than thin ones ; in such cases the small store of fat is quickly consumed and the albumin is rapidly called on.

Carbohydrates.—These are compounds of carbon, hydrogen, and oxygen. The oxygen is present in the proportion required to form water with the hydrogen. During digestion starch, cane sugar, dextrine, and milk sugar are transformed into grape sugar or glucose before they are absorbed, and in this form they are much more metabolised than the fats or proteins. The excess of sugar is stored up in the liver and muscles as glycogen. The glycogen of the muscle disappears in proportion to the work done, and prolonged muscular work especially during starvation may wipe out the entire store of glycogen in the body. The oxidation of sugar therefore furnishes energy which by the machinery of the muscles is utilised to do work. This oxidation plays an important part in the supply of heat needed by the body. Each grain of sugar yielding 4 calories of heat, and since carbohydrates form the major portion of our diet and are easily oxidised, they form an important factor in the maintenance of animal heat.

The carbohydrates therefore play the same rôle as fats in food, being sources of heat and energy, and are more easily taken up into the system than any other class of food. They are also a source of fat, but in ordinary diets they are utilised immediately as sources of energy.

Vegetable Acids.--Although these are not, strictly speaking, foods, they are necessary for the preservation of health : the chief ones being tartaric, citric, oxalic, and malic acids. Vegetable acids are mostly derived from fresh fruits and vegetables, and by forming carbonates in the system they help to preserve the alkalinity of the blood and other fluids. By oxidation they help the body to maintain a certain amount of heat and energy.

Mineral Salts.--These are of great value to the body and are as essential to nutrition as the proteins. They include common salt, phosphates of lime, soda and potash,

magnesium and iron. Of these sodium chloride or common salt is very important and occurs in all the tissues and fluids of the body. It enters into the formation of hydrochloric acid of gastric juice, and bile salts, and is absolutely necessary for existence, and its complete withdrawal from food would prove speedily fatal. A large part of it is taken in meat, bread, etc. The phosphates of sodium and potassium are important salts ; the blood plasma and other fluids owe their alkalinity partly to these alkaline phosphates. Sodium carbonate and bicarbonate are also found in the plasma. They are taken in small quantities with the food and partly formed in the body by the decomposition of the salts of the vegetable acids. They carry CO_2 from the tissues to the lungs. Calcium phosphate is essential for the development of bones and is very important for the young. Calcium salts also play a most important rôle in connection with the irritability of muscle and nerve. The best source of lime salts is milk, and next to milk is egg. Rice is also an important source of calcium. Iron is an essential element of hæmoglobin, and therefore of the red blood cells. It is also found in the muscles and in other tissues in minute quantities.

All these mineral substances are introduced into the body as constituent parts of the various ordinary articles of human food, animal or vegetable, with the exception of common salt, which is usually added to various foods in greater or smaller amount in addition to what they may themselves contain.

Vitamins.—Observations made by Funk and others show that in addition to the different proximate principles, there are certain accessory materials that are necessary either because they play some important rôle in the synthesis of the body, or influence in some indirect way the normal direction and character of the metabolism. It has been shown that beriberi is caused by a diet exclusively of polished rice, *i.e.* rice from which outer layers of the grains have been removed. If however the polishings are restored to the diet the condition disappears. It is believed that the polishings contain some material

essential to body metabolism. Funk has isolated from the polishings of the rice, and from many other ordinary foods a nitrogenous base resembling in structure the *pyrimidin* bases found as one component of nucleic acid, and this he has named *vitamin.* It is the lack of this accessory in polished rice which makes this material when taken alone an inadequate diet. It is therefore almost proved that these accessory substances are essential to normal growth and maintenance. The part that they play in normal metabolism is not clearly understood, and it has been suggested that they act in the manner of *hormones.*

Vitamins have been classified into :—

(*a*) Antineuritic or the *Water-soluble B*

(*b*) Antirachitic or the *Fat-soluble A*

(*c*) Antiscorbutic or *Water-soluble C*

(*a*) *Antineuritic or Water-soluble B.*—This vitamin prevents the occurrence of beriberi in man and analogous diseases in animal. It is found to some extent in all natural foodstuffs, especially in the seeds of plants, in eggs and fish. Milk, cheese and potatoes yield less antineuritic vitamins, while yeast, even autolised and filtered, retains large quantities of the vitamins which will rapidly cure experimental polineuritis. The anti-neuritic vitamins are slightly affected by high temperatures. At 100°C., which is comparable with ordinary cooking processes, the anti-neuritic property of wheat germ is slightly diminished, and at 120°C., which is attained during the sterilisation of human food, as in canning, destruction is much more rapid.

(*b*) *The Fat-soluble A or antirachitic vitamin* promotes the growth and prevents rickets in young animals. The main sources of this vitamin are (i) certain fats of animal or vegetable origin, and (ii) green leaves. They are found in abundance in cream, butter, beef, fat, cod-liver oil and yolk of egg. Pea-nut or arachis oil is supposed to contain this vitamin in large amount.

(*c*) *Antiscorbutic vitamin.*—This is necessary for the prevention of scurvy and is found in fresh vegetables and animals. Its richest sources are cabbages, turnips,

lemons, oranges and tomatoes. Milk and meat possess a definite but low antiscorbutic value. The antiscorbutic vitamin differs from the anti-neuritic one in its distribution and properties, as well as in the nature of its influence on nutrition. This vitamin is less widespread than the anti-neuritic vitamin, and is more sensitive to heat and drying than the antineuritic one. Tinned foods which have been raised to a temperature of 120°C. lose their antiscorbutic properties. It has also been shown that although dried pulses contain no antiscorbutic principles while still dry, the antiscorbutic elements develop in 48 hours if they are moistened, kept warm and allowed to germinate. All dry foodstuffs are deficient in anti-scorbutic vitamins. The tissues of fresh vegetables dried at low temperature or their expressed juices preserved in the cold rapidly lose their anti-scorbutic property.

Water.—This is an important article of diet and forms 64 per cent. of the body weight. The daily loss from the system is about 100 oz. It is taken separately, as also with the solid foods which contain it. Water is necessary to compensate for the losses caused by the excretory organs, and for the repair of the various fluids and of the solid organs of the body into whose constitution it greatly enters. It is also a vehicle for the solution and dilution of solid foods whereby they are more easily digested and assimilated. The amount of water needed by the body depends on various circumstances, especially on bodily temperature and bodily labour. The greater the functional activity of the bodily organs the more is the need for water. The temperature and humidity of the air, as also the nature and amount of solid food taken, also increase the necessity for the taking in of water. The need for water is indicated by thirst. An insufficient supply of water leads to disturbances of circulation, and of the heat regulating mechanism, and also to retention of products of metabolism. A free supply of water promotes the circulation of fluids, accelerates albuminous metabolism, and increases the activity of the kidneys with free secretion of the urine.

Necessity for a Mixed Diet.—From what has been said it follows that the maintenance of the body in a healthy condition depends upon a mixed diet, which combines all the proximate principles, viz. proteins, fats, carbohydrates, and salts. The proteins are the principal ones, as without them no vital action can be carried on ; on the other hand, an excess will cause a rapid oxidation of fat. Increase of fat and carbohydrates lessens the absorption of oxygen. Health cannot be maintained on proteins and water alone, but at the same time a person cannot be healthy without them.

Quantity of Food required in Health

In the selection of diet for a healthy man doing average work it is necessary that the food should contain sufficient energy with an average 3,500 calories, and must provide for the upkeep and repair of the tissues of the body. The amount of food necessary to maintain the body in a state of health and activity depends upon a number of circumstances, and can be arrived at either by a *physiological* or an *empirical* method. The physiological method is based upon estimations of the intake and output of the chemical constitutents of the food, and the amount of potential energy expended daily in the production of heat and muscular work.

Standard dietaries are dietaries based upon the results yielded by the first method, and those which result from the second are **actual dietaries.** It should be noted, however, that these standard diets have a very limited application ; they are useful in furnishing one with some data of the amount and kind of food to be given to a healthy person doing a moderate amount of work. This is especially important in connection with the management of poor houses, schools, jails, and the like. In the cases of individuals, however, certain modifying factors, such as age, sex, height, build, work, etc., have to be considered.

Age and Sex.—Building material, fuel and muscle food are more needed by children than adults, because they have got to add to their tissues by growth in addition to keeping them in repair. Women require relatively less

food than men on account of the lighter nature of their work, and also perhaps from their possessing a slower metabolism.

Just as children require a large amount of food so with the aged the reverse holds good. At this age the power of assimilation is on the wane, and bodily activities on a decline, and so the diet should be smaller than that of middle age.

Height and Build.—The amount of food required varies with the body weight and the extent of the body surface. A heavy man requires more food than a light one. Again, more heat is lost if the body surface is great and consequently a larger supply of fuel is required.

Work and Rest.—In ordinary life the amount of food needed depends more upon the muscular activity than on any other factor. It has been shown that a greater performance of bodily labour calls for an additional supply of proteins and carbohydrates in the food. On the other hand, during complete bodily rest, as during illness, the demand for potential energy may fall to 2000 calories or less per day.

Mental work does not increase bodily waste to any appreciable extent ; quality and easy digestibility are more needed by brain workers than mere quantity.

Climate.—Owing to the greater loss of heat more food will be required in cold climates than in temperate ones, and more in the temperate climates than in the tropics. In very hot weather the appetite is lessened and less food is taken and consequently there is some loss of weight. In cold climates and in winter the heat-supplying foods, especially those rich in fat, should be increased, while in the opposite conditions there should be more carbohydrate and less proteins and fats.

The Relative Value of Foods

The relative value of different foods must be considered on chemical, physiological, and economic grounds.

The *chemical value* of food is estimated by the results of percentage analyses. But the nutritive value of food

cannot be judged from its chemical composition alone. While food with a small percentage of nutriment cannot be regarded as a valuable article of diet, a high chemical value alone does not imply suitability to the needs of the body.

The value of food from a *physiological* standpoint depends on the digestibility and absorbability of food.

Digestibility of Food.—This depends on two factors :—

1. The food must be in a fit state to be digested.
2. The physical and chemical conditions in the body must be appropriate.

A mixed diet is easily digested ; fat taken with meat helps the digestion of the latter. Food accessories like condiments, etc., also help digestion. Palatability of food is not simply a gratification of the sense of taste and pleasure. An appetising food, or even the idea of it is sufficient to make the mouth water, *i.e.* increases the flow of saliva, and at the same time produces in the stomach what has been termed by Pawlow "appetite juice." Moreover, the increased production of saliva in its turn tends to increase the secretion of gastric juice, this again stimulates the duodenal mucous membrane and leads to the production of the hormone *secretin.* As the result of experiments on men commoner foods are arranged according to the length of time which they take to disappear from the stomach.*

1 to 2 hours

7 oz. of water or plain tea, coffee, or cocoa.
7 oz. of boiled milk.
7 oz. of beef tea.
Whites of three eggs.

2 to 3 hours

½ pint beer or boiled milk.
A large teacupful of coffee with cream, or cocoa and milk.
2 raw poached eggs.
5 oz. boiled white fish.
7 oz. cauliflower or asparagus.
5 oz. boiled or mashed potatoes.
2½ oz. white bread.
2 oz. biscuits.

3 to 4 hours

3 oz. stewed chicken.
5½ oz. any sort of bread or biscuit.
5½ oz. rice, apples, or carrots.
9 oz. boiled beef.

* Green's *Encyclopœdia of Medicine and Surgery*, vol. ii.

Absorbability of Food.—The absorbability of the food in the intestines must be distinguished from digestibility in the stomach. By *digestion* is meant the production of simpler bodies which are presented for absorption, but the actual amount of absorption depends upon certain physical factors, *e.g.* osmosis, diffusion, etc. Therefore a food that is easily digested is not necessarily that which is completely absorbed, and *vice versa.* Carbohydrates and fats are more easily absorbed than proteins, and animal proteins more readily absorbed than the vegetable ones. It should be noted, however, that part of the food should remain in the intestines to act as a " ballast " to stimulate peristalsis.

The *economic* consideration of food is of great value. A good food is one that contains high nutritive value, and is easily digested and absorbed, cheapness not interfering with its qualities.

Time for Taking Food.—A diet with all the proximate principles may with advantage be taken three times a day. It takes about 4 to 5 hours to digest an average European diet, and 7 to 8 hours an average Indian one. But in either case this varies with the kind of food taken. During youth, when the digestive functions are comparatively active and rapid, the intervals should be shorter than during adolescence. Indians as a rule take two principal meals, the breakfast in the day, and the dinner at night. A morning meal is always necessary, for so long a fast after the last meal at night under the modern conditions of life is rather exhausting and injurious. The body becomes more susceptible to morbid influences, especially to cold, and other infections. There should be a sufficient interval between the last meal and bed time. Regularity in the time of taking food is important. In some cases the desire for food occurs with all the regularity of the clock, and if the food is not taken at that time the appetite disappears.

The Fuel-value of Food.—Food material burnt in the body produces certain amount of heat which is expressed as the *calorie,* and is the amount of heat required to raise 1 litre (*i.e.* 1 kilogram or $2\frac{1}{4}$ lb.) of water 1 °C. It has been

shown that the heat value of 1 grm. of protein and 1 grm. of carbohydrate is 4.1 calories each , and 1 grm. of fat is 9.3 calories. Calculating on this basis the heat value of a diet consisting of 100 grm. of protein, 100 grm. of fat and 500 grm. of carbohydrate would be :—

$100 \times 4.1 + 100 \times 9.3 + 500 \times 4.1 = 410 + 930 + 2050 = 3{,}390$ calories.

Cooking of Food

We now pass on to consider in what way these different articles of food can best be made to yield the full amount of the nutrition they are capable of affording. Of the various definitions suggested of "man" he has been called "a cooking animal," and man is the only animal that uses fire and prepares his food before he eats it. Cooking is both an art and a science, and good cooking implies knowledge and skill. Cooking answers most valuable purposes in connection with food. It increases the palatability of food and enables it to be more readily masticated and easily digested. By improving the appearance of the food it renders it more appetising. A number of vegetable products that would be too hard for digestion are rendered softer, and protein foods are made more palatable and digestible. Certain pathogenic microbes with which the food may be infected are killed by this process.

Potatoes, roots, green vegetables, etc., are boiled in a bath of water, and this involves a great loss, as the bulk of the valuable mineral salts are drained away. Boiling of all operations of cookery is that which calls for the most careful judgment, and that method of boiling which causes no loss at all is the best, and this result is only attainable by cooking in dry steam.

There are at the present time many different kinds of apparatus for steam cooking, but the parent of them all was the cooking pot invented by Captain Warren, and all steam cookers are more or less built upon the Warren principle. The saving thus effected is proved by the fact that a cooked joint of meat with gravy will weigh just the same as the raw joint when put into the cooker.

Cooking therefore, is almost always an advantage, but there are instances where the reverse is the case. Oysters contain a digestive ferment sufficient to digest themselves, but when cooked not only is this ferment destroyed but the flesh becomes tougher.

Diseases connected with Food

Articles of food when exposed to the open air undergo all sorts of contaminations, hence it is absolutely necessary that foods, whether in the shop or in the house, should be kept in suitable receptacles in such a manner as will prevent the risk of contamination from dust, flies, and other insects. There are again other diseases like scurvy, beri-beri, pellagra, ergotism, lathyrism, etc., connected with the consumption of certain foods, and not due so far as is known to any parasites introduced with food.

Apart from the presence of the ordinary poisons, food may be posionous on eating—(*a*) naturally, *e.g.* mushroom, certain fish ; (*b*) from the results of the activity of micro-organisms with the formation of toxic products, the ordinary "ptomaine poisoning ," (*c*) from infection with certain organisms, particularly *B. enteritidis*, which generally induce gastro-enteritis, and *B. botulinus* giving rise to a train of symptoms known as *botulism*. This germ is anaerobic, and generates the toxin by acting only upon protein matter, both animal and vegetable. The poison is not self-generated, but the result of direct inoculation of the food before tinning, canning or earthenware jarring. Food may convey foreign poisons which may be metallic poisons, or chemicals used as adulterants. Presence of certain specific or parasitic diseases such as tuberculosis, trichinosis, etc., may impart the disease, when the flesh or milk of such animals is eaten. Foods may not be poisonous in themselves but may have an injurious effect to persons with weak digestion, thus shell fish, eggs, tomatoes, etc., often produce symptoms resembling anaphylaxis in sensitised persons.

Excess of Food.—If too much assimilable material is taken, the organs concerned in the metabolic processes

have too much work thrown upon them, and if they are able to perform the task the blood becomes surcharged with oxidisable matter. The overloaded condition of plasma acts as an irritant either to the vessel walls or to the vasomotor centre, producing constriction of the arterioles, and a consequent general rise of blood-pressure. The task of excreting the excess is undertaken mainly by the kidneys, and the amount of work thrown upon, them is out of proportion to the physiological necessities, so that sub-oxidation and deficient excretion results leading to dyspepsia, gout and constipation. Fermentative and putrefactive processes are set up with the generation of offensive gases leading to dyspeptic troubles. These may be attended with either constipation or diarrhœa. Some of the products of putrefaction are absorbed into the system and give rise to symptoms of auto-intoxication. If fat or carbohydrate be in excess in the food, they seem to set up acid dyspepsia with accumulation of much flatus. Fat is also deposited in the tissues and persons suffer from obesity.

Deficiency of Food.—Deficiency in all the proximate principles of diet involves loss of weight, debility, poverty of blood, and prostration. Complete deprivation leads to rapid wasting, dryness of the mucous membrane, impaired action of the heart and respiratory system, low fever, restlessness, delirium, coma, and finally death. Young subjects bear starvation badly and die very soon. Absence of fat leads to a state of malnutrition. Continued starvation produces the most disastrous effects on the human constitution, and the digestive functions become so altered and degenerated from disuse that when a sufficiency of nutriment is given the wasted organs cannot utilise it and the sufferer dies from inanition.

Rickets.—Recent experiments indicate that rickets is a deficiency disease in consequence of the absence of some accessory food factor or factors. The antirachitic substances for the most part have been found to be similar to those in which *fat-soluble A* vitamin is present. It seems probable that rickets is caused by an inadequate intake of antirachitic vitamin which is either *fat-soluble A*,

and intimately connected with growth, or a factor of somewhat similar distribution. On the other hand other observers see no relation between diet and rickets, and ascribe the disease to unfavourable environment, too limited air space, and lack of exercise.

Scurvy.—Considerable amount of work has been done of recent years upon scurvy and other deficiency diseases, and like beri-beri it is a deficiency disease due to the long continued consumption of food lacking in an accessory food substance or *vitamin.* The view that it is due to tainted food is no longer accepted. Antiscorbutic vitamin is obtained in large quantities in oranges, lemons and fresh green vegetables, in roots and tubers, and in small quantities in fresh milk and meat (*see* p. 131.).

Pellagra.—Recent observations point to pellagra being the result of deficiency in diet, thus bringing it into the same category as other well-known deficiency diseases, such as beri-beri and scurvy. It is a disease of malnutrition caused by a deficiency in the biological value of proteins, and may be wholly eradicated by proper feeding. The probable deficiency is that of some aromatic amino-acids possibly *tryptophane.* From observations made in the Russian and Roumanian fronts it has been shown that where there was pellagra the chief article of diet was mainly maize or maize flour. It has been asserted that the association of pellagra with the consumption of maize is not due to the maize, nor to any toxin contained in it, but to the low biological value of maize protein. Some however believe it to be due to a maladjustment in the elements of the dietary rather than to a lack of some special vitamin. The different ways in which a diet may be ill-balanced or maladjusted have been classified by McCollum as follows :—1. An inadequate supply of the necessary inorganic constituents. 2. Inadequate amounts of protein, or the use of protein of poor quality, *i.e.* not containing all the necessary amino-acids. 3. A lack or deficiency in one or both of the accessories, fat-soluble A and water-soluble B. 4. The presence of toxic substances in certain foods.

CHAPTER VIII

DIET IN INDIA *

THE consideration of the subject of dietary with special reference to India is a very difficult problem. A country inhabited by people of different nationalities, castes and creeds, habits and customs, physical growth and development, naturally shows a divergence in the food they eat. Hindus from time immemorial have got into the habit of living purely on a vegetable diet. Although there is less prejudice in recent years against taking animal food as part of their daily diet, meat is not taken habitually by the majority of Indians. Pure vegetarians are found in many parts of India enjoying the best of health. But it should be noted that milk, though derived from the animal kingdom, is not excluded from the diet of even the strictest vegetarian Hindu ; eggs, however, are not eaten by any of these vegetarians.

NUTRITIVE VALUES

Before going into details let us analyse the nutritive value of vegetable food. Based on chemical composition alone the proteins, carbohydrates, and fats of vegetable food are almost equal in nutritive value to the corresponding substances derived from the animal kingdom. Vegetable protein, however, contains a smaller proportion of carbon, which circumstance, according to Chittenden, makes it inferior in nutritive value to proteins of animal nature. On the other hand some German observers have shown that the nitrogen equilibrium suffers no impairment if the proteins of meat and milk be replaced by a similar quantity of protein in the form of peas and beans.

* B. N. Ghosh, *Journal of the Royal Institute of Public Health,* London, May 1911.

As regards carbohydrates, it is enough to say that they are almost entirely derived from the vegetable kingdom, and their value as food is beyond any dispute. With regard to fat it has been proved by experience and experiments that vegetable fats are as valuable a means of nourishment as the fats of meat or milk.

It must not, however, be supposed that simply because the chemical constituents of vegetable food are equal in nutritive value to the corresponding constituents of animal food, vegetable food can replace animal food or *vice versa*. For instance, a glass of whisky is chemically the same whether it is taken raw or diluted, but the effects are markedly different. The real question to consider is that of protein absorption of a vegetarian, for carbohydrates must of necessity be derived from a vegetable source.

Standard Vegetarian Diet

Let us now consider some standard vegetarian diet, and for this the ordinary jail diet of Bengal may be taken as a type, which consists of :—

Rice	..	26.65 oz. or	755.80 grm.
Dals ..	..	6.15 oz. or	174.41 grm.
Vegetables	..	6.15 oz. or	174.41 grm.
Mustard oil	..	0.64 oz. or	18.11 grm.
Condiments	..	0.26 oz. or	7.37 grm.
Antiscorbutic	..	0.26 oz. or	7.37 grm.
Salts ..	..	0.90 oz. or	25.52 grm.

The value of this diet in proximate principles is as follows :—

Foodstuffs	Rice.	Dal	Vegetables	Oil	Total (in grm.).
Protein	51 63	39 32	2 36		93 31
Carbohydrate	589 55	94 72	9 06		693 33
Fat .	6 80	4.76	1 58	17.35	30 49

The above therefore represents the average composition of the diet in use in the Bengal jails, and according to the accepted heat equivalents its caloric value is 3508,

which is about 1000 calories higher than is furnished by Ranke's diet. In the above diet the total bulk is so great that digestion and absorption are interfered with, and only a portion of the 93 grammes of protein is actually utilised by the system , in fact, the real nutritive value of the above diet is little more than 60 to 65 grm. But the effect of adding wheat-atta, fish, or meat to the above diet, diminishing at the same time the amount of rice and dal, was much better, with the result that there was a sudden rise of the protein absorption, the actual protein metabolism being largely augmented.

Thus on a diet consisting of

Rice	..	18 oz.	Atta	..	4 oz.
Dal	..	5 oz.	Vegetables	..	6 oz.

the average metabolism was 8.50 grm. of nitrogen daily. In fact, the protein metabolism was considerably increased with a diminution of about 50 per cent. of nitrogen residue in the stools. The reduction of rice from 26 oz. to 18 oz. daily helps to bring the carbohydrate element and the total caloric value of the diet within the bounds of physiological limits, and assists in reducing fermentation in the intestines.

It is believed that Mahomedans, who are used to animal diet, are better able to absorb the protein from an animal food than are Hindus, who are largely vegetarians. As a result of investigations by McCay* upon Mahomedans and Hindus placed exactly on the same diet, identical results were obtained. The diet was as follows :—

Bread	..	..	..	8 oz.
Mutton	..	..	..	12 ,,
Fish	..	..	..	6 ,,
Potatoes	..	..	..	4 ,,

The value of this diet in nitrogen is 16.29 grm. McCay believes that the degree of nitrogen absorption depends more upon the manner in which the protein diet is made up than upon the absorptive power of the intestinal canal.

* "Scientific Memoirs," Government of India, No. 37, 1910.

Food and Physical Development

We are now in a position to consider the question of the relationship of food to physical development. From the researches made on the metabolism of the Bengalis and on their nutrition, it is evident, "that the average native of Bengal, even the members of the well-to-do classes, exist on a metabolism of less than 4 grm. of protein per man daily on the ordinary diet of the province." The opinion that the sociological conditions, vigour, and physical development of a race are in close relation with the amount of assimilable protein, is almost unanimous. The progress of a nation will be hampered if the citizens are ill-fed, for upon food depends not only life itself, but the power to work and to resist disease. The quality and sufficiency of food have therefore a far-reaching influence upon the development of the race, an influence which is directly seen in the physical well-being associated with an adequate supply of suitable food. The result of protein starvation especially in the early growing period of life, when in addition to the elements required for repair and formation of energy an extra quantity is required for growth, is disastrous, for this may result in imperfect growth and development, the consequences of which may be very lasting. With the rice-eating inhabitants of Bengal there is a loss of tissue protein with an accompanying loss of vigour and strength and a comparatively low capacity for prolonged or sustained muscular work. It is therefore of vital importance to consider the particular diet that will suit the people of Bengal. More assimilable protein, and not excess of carbohydrate, is what is needed in the diet. But it does not follow that protein from meat alone should be given to build up the tissues of the body. Instances are not wanting where people show marked physical development by living exclusively on rice, atta, dal, cream, milk, etc. The people of Bengal living entirely on vegetable food, mainly rice and dal, for ages, have got quite used to this diet. If we look to the history of the human race, we find that man has been guided in the

selection of his food by the circumstances and conditions with which he has been surrounded. The physical organisation seems capable of the remarkable power of adapting itself to such food as may be procurable. Thus, in Arctic regions where no vegetables can be had man lives exclusively on meat and fat ; similarly in India where fruits and nutritive vegetables abound, and are easily procured, these are consumed very largely.

There is another side of the question, viz. there are degrees of health, and that while health and muscular strength can be maintained upon a purely vegetable diet, a careful consideration will show that those who live on such a diet are lacking in what is called energy. One must carefully differentiate energy from strength. The former is a property of the nervous system, the latter of the muscle. Carbohydrates derived from vegetable food supply the muscles, whereas the brain requires nitrogen which is obtained from the protein food only. Energy and strength derived from animal and vegetable food are very well explained by the following lines of Haughton : "The hunted deer will outrun the leopard in a fair and open chase, because the work supplied to its muscles by the vegetable food is capable of being given out continuously for a long period of time ; but in a sudden rush at a near distance, the leopard will infallibly overtake the deer because the flesh food stores up in the blood a reserve of force capable of being given out instantaneously in the form of exceedingly rapid muscular action." One of the objections to living purely on vegetable food is that one has to consume a much larger quantity of vegetable than of animal food to obtain the necessary amount of nourishment, for, as has been shown above, a large amount of protein would pass out of the body unutilised, and the albumin of vegetable substances is often mixed up with large quantities of starch enclosed in a network of cellulose which is resistant to the action of digestive juices. It is generally believed that high protein consumption ensures greater resistance to infection, and that epidemics are more common amongst ill-fed vegetarians, but Carter of Birmingham found that the incidence of tuberculosis

had no relation to the protein of the diet, whereas it was clearly related to poor energy value. The real fault appears to be on the lack of quantity; not in quality.

Physiological Effects

The physiological effects of the increased bulk of vegetable food call for some consideration:

1. The stomach and bowels become somewhat distended, as evidenced by the disproportionate development of the abdomen of herbivorous animals, and also in the so-called "potato-belly" of the Irish peasants and the fat belly of the Indian vegetarians. But this increase in capacity of the abdominal organs, by which the greater bulk of a vegetable food is compensated for, is not accompanied by an increased power of digestion and absorption.

2. The manipulation by the stomach and intestines of a large bulk of vegetable food necessitates increased muscular efforts by these organs, which implies a large expenditure of blood and nervous energy, and, consequently there is less of these left for other purposes, especially for the use of the brain.

3. The increased amount of water which is an important feature of vegetable food, is also a disadvantage, for this does not lessen the intake of water; on the other hand, it renders the tissues more or less flabby and dilutes the blood.*

It may be mentioned that increased vegetable food has little influence on those engaged in out-door work than one engaged in sedentary pursuits. For a labourer requires a large amount of carbohydrate to perform muscular work, and the free action of the skin carries off the excess of water which such a diet contains.

Daily Diet

Admitting, therefore, the value of proteins in the diet, and that the animal protein is the most assimilable of all, the question which naturally suggests itself is what should be the diet of the people of Bengal. Is it possible to live

* Hutchison's *Food and Principles of Dietetics.*

on the same diet as Europeans do in India? Voit and Craemer pointed out that persons who have for years been accustomed to one form of diet absorb its constituents no better than those to whom such a regimen is a comparative novelty. As the result of investigation on Hindus and Mahomedans, McCay corroborates the above statement. But we find that the testimony of some experienced medical men is quite different: "It has often been said that Europeans in India should imitate the natives in their food, but this opinion is based on a misconception. The use of ages has accustomed the Hindu to the custom of taking a large quantity of rice with pulses and corn. Put a European on this diet and he could not at first digest it. The very bulk would be too much for him."* Again, no less an authority than Sir Joseph Fayrer makes the following observations: "It is not advisable to copy the natives in respect of diet. Neither the mode of living nor the quality nor the quantity of the aliment can be changed with impunity. The stomach of the Anglo-Indian will no more obtain from the dietary of the Hindu all that is necessary for nutrition than it could in other circumstances from the blubber that delights whilst it nourishes the Eskimo." If the above is true for Europeans, the reverse should hold good for Indians. Pawlow has shown that the pancreas pours out a secretion whose properties vary with the food supplied. If the animal is fed on meat the secretion becomes rich in trypsin, and if the diet be starchy the proportion of amylopsin in the juice becomes greater.

Supplementing the Protein Element

We have now to consider how the deficiency of the protein element can be supplemented. There are three methods by which this can be done :—

1. By adding a moderate amount of food derived from the animal kingdom. In meat and fish we have concentrated forms of protein foods and by their use we can supplement the nitrogenous element which would otherwise be deficient in the diet. This diet is best suited

* Burney Yeo's *Food in Health and Disease.*

for Europeans in India. In a suitable mixed dietary the proportion of animal food should be less than 25 per cent., and according to Voit it should be 35 per cent.

2. Some vegetarians supplement the protein of their diet by taking milk or eggs. In fact, milk and its preparations are taken by most of the vegetarians in India. A liberal use of milk will no doubt remedy certain deficiencies of a vegetable diet, and there can be no physiological objection, except the difficulty of obtaining it pure, when the question of expense has also to be considered. This form of diet with the addition of fish may with advantage be recommended for the Indian people.

3. For those who do not even take milk or fish, or cannot afford to have them, the only method of increasing the total protein is by taking large quantities of such foods as are especially rich in nitrogen as atta, pulses, etc. For them the diet discussed on page 142 is useful. But the disadvantages of such a diet, necessitating consumption of a large bulk of food, have already been alluded to.

A diet, therefore, that will suit the average Indian and at the same time maintain the high standard of protein metabolism would be a compromise between the European and the orthodox Hindu diet. The following diet may be recommended for persons doing medium work :—

Rice ..	8 oz.	Fish ..	4 oz.
Atta ..	6 ,,	Vegetables ..	6 ,,
Dal ..	4 ,,	Milk ..	12 ,,
Butter or Ghee	3 ,,		

The approximate value of this diet in proximate principles is as follows :—

	Protein.	Fat.	Carbohydrate.
Rice	0 4	0 064	6 60
Atta	0.66	0.12	4 26
Dal	0.88	0 08	2 12
Ghee	0 03	2 7	.
Fish	0 73	0.12	.
Vegetables	0 36	0.054	2 1
Milk	0 48	0.44	0.57

The following table shows the comparative value of this diet with the standard diet of Moleschott :—

	Moleschott.	Author's diet
Protein	4 59 oz	3 53 oz
Fat	2 96 ,,	3 568 ,,
Carbohydrate	12 20 ,,	15 65 ,,

It should be noted that the diet of rice, wheat, lentils, etc., used by the majority of Indians is well suited to the climate and to their constitution. The defect in the orthodox Hindu diet is its poverty of the protein element. The addition of wheat atta to one of the two daily meals materially improves the condition. During the hottest months many Europeans take meat very sparingly. In fact, there is less craving for animal food in hot weather, and also a less capacity for digesting it, especially when it is of a fatty nature.

The diet of Europeans in India should also be modified. It is not a sound practice to live on a purely European diet in India. In a suitable mixed dietary the proportion of animal food should be less than one in four. If this is exceeded, an undue strain is imposed on the eliminatory organs and the liver. The following are the remarks of Professor Simpson on the subject : "When the Aryans first descended into the plains of India they were meat-eaters, but the experience of the centuries evidently taught them to be vegetarians, or to be very sparing in the amount of meat they eat, and at the same time to become total abstainers. This is an experience, the lessons of which the Europeans who go to the tropics are inclined to ignore. Accustomed to living well in their own country, in which large quantities of meat, fats, and rich food as well as wines and spirits form an important part of their diet they are tempted to continue as closely as possible a similar diet in the tropics."

The main points that have been discussed may be summarised as follows :—

1. Vegetable food is rich in carbohydrate, and with some exceptions, deficient in fat and nitrogenous substances.

2. Vegetables are bulky, due to richness in starch and cellulose and to the large amount of water which they contain.

3. Some that are compact in their raw state become bulky on cooking.

4. They are less easily digested and less completely absorbed than animal food, due to bulkiness and their tendency to undergo fermentation in the intestines, with production of acid bodies which stimulate peristalsis.

5. A vegetarian must either live upon a diet poor in protein or consume a large bulk.

6. Meat, fish, egg, milk, *chhana*, etc., may be used to supply the deficiency of the protein element, and for healthy persons a moderate use of fish, milk, or meat may be of advantage.

7. Both from a chemical and physiological point of view a purely vegetable diet (milk excluded) is apt to be deficient in protein element.

8. The best results are obtained by supplementing part of the vegetable food by animal substances rich in protein, and this is done by taking either fish, milk, or any of its preparations ; in fact two-thirds of the total protein may safely be taken in the vegetable form.

CHAPTER IX

VEGETABLE FOODS

FOODSTUFFS are naturally divisible into two groups: those derived from the vegetable and those from the animal kingdom.

The most prominent feature of vegetable foods is the large proportion of carbohydrates which they contain. But it must not be supposed that vegetable foods are merely carbohydrates; they contain protein and fat as well, and some, especially the pulses, are rich in protein, while others, as nuts, are rich in fat.

Vegetable proteins mainly belong to the class of globulins, and are dissolved in water with a little sodium chloride. Nucleo-proteins are less in vegetable substances than in the animal tissue. But vegetable proteins are comparatively poorer in carbon and richer in nitrogen.

Both animal and vegetable proteins are rendered less digestible by cooking, and while cooking diminishes the digestibility of animal foods it increases the digestibility of vegetable foods. This is due to the fact that animal food contains chiefly proteins, while vegetable food contains proteins to a less extent than carbohydrates in the form of starch, which as we shall see is rendered more easy of digestion by cooking.

Vegetable fat is the most concentrated of all the non-nitrogenous materials that are evolved in plants, and is one of the most convenient forms in which such materials can be stored. It resembles animal fat in composition and is produced by the action of fatty acids upon basic glycerol radical. The presence in excess of the "lower" fatty acids (olein, linolein) in the substance of some of the vegetable fats gives them a free and liquescent consistency which is known as "oil";

while the presence, to a similar extent, of the "higher" fatty acids (*e.g.* stearin, palmitin) in that of some other of the fats from plants, causes the dense and granular solidity which is associated with the usual consistence of fat.

Vegetable fat is of prime importance in the economy of the human race. A necessity of existence in all cold countries, fat, in the shape of oil or butter, is largely consumed as human food. Excepting olive or such other vegetable oils, the majority of fats consumed in them are derived from purely animal sources, whereas, with the exception perhaps of ghee in India, the greater number of oils utilised in the tropics are of purely vegetable origin. The vegetable oils are expressed from various seeds and are used either for cooking or in place of butter. The oils chiefly used are derived from the mustard seeds; the ground nut (*Arachis hypogea*), cocoanut, soya bean, til (*Sesamum indicum*), kokam butter or mangostin oil (*Garcina mangostana*), etc.

The popular belief that an animal fat alone is a butter is erroneous, inasmuch as many true butters are derived from plants, and those from the cocoanut are not only by far the most important but are increasing in value day by day.

Carbohydrates of vegetable food exist chiefly in the form of starch and sugar. It is in the form of starch that carbohydrate is stored up in the plant, and this abounds in all plants, particularly in the seeds of cereals and legumes, and in potatoes and other tubers. Starch is more appropriately the surplus carbohydrate, and cannot be utilised as such by the plant. It is in the form of sugar, the soluble carbohydrate, that it circulates in plants. When needed by the plant, part of this starch is converted into sugar by the ferment diastase, and circulates in the plant just in the same way that it undergoes changes in the body.

Starch is not soluble in water, and thus is rendered possible its storage in the plant; moreover starch is a more concentrated form of carbohydrate than sugar.

With boiling water the starch grains swell and burst and form a gelatinous solution. By the process of cooking,

these starch granules are broken up to be more easily acted upon by the digestive juices. Just as proteins, the nutritive constituents of meat, are enclosed in minute tubes of connective tissues, so also starch, the chief ingredient of vegetable food, is enclosed in a network of cellulose. Cellulose is a carbohydrate but is resistant to the action of digestive juices. When old it becomes woody. It is obvious, therefore, that it must present a great obstacle to the penetration of the digestive juices.

The common forms of vegetable food may be divided into: (1) Cereals, (2) Pulses, (3) Roots and Tubers, (4) Green Vegetables, and (5) Fruits and Nuts.

I. CEREALS

Cereals belong to the tribe of grasses, and the use of the seeds is widely spread over all parts of the globe, as a valuable article of food. Of these wheat is mainly used in Europe, maize in America, and rice, maize and millet in India. These seeds not only contain a large quantity of nutritive material condensed in a small bulk, but also a considerable proportion of mineral substances, the most important being the phosphates of calcium, magnesium, potash, etc., with a small amount of iron and silica. The different nutritive ingredients—protein, carbohydrate, and fat—are represented in cereals although they are rich in nitrogenous substances, starch, and cellulose, and poor in fat.

The seeds are usually ground into meal when utilised as food. This process, besides reducing the hard seeds into powder, removes the outer indigestible coat which is composed of woody cellulose.

It should be noted that maize is relatively rich in fat and slightly deficient in salts; rice is very rich in starch but poor in nitrogenous substances, fat, and mineral matter; oats, on the other hand, are especially rich in fat and protein, and rank as the most nutritive of all cereals. Millets are inferior to wheat in the proportion of proteins, but superior to it in fat. But the preponderance o carbohydrate in all cereals precludes these being used

alone ; in fact, they should be eaten with other foods rich in fat and protein. As a rule they are very easily absorbed and are not only compact but possess high nutritive value, which places them in the front rank of all human foods.

The composition of some of the common forms of cereals is shown in the following table :—

	Gross protein.	Available protein.	Avl. Fat	Carbo-Hydrate	Mineral matter.	Calorie per ounce.
Oatmeal	15.0	12.0	7.0	64	2.0	108
Barley	10.0	8.0	2.2	69	2.4	97
Millets	8.2	6.6	4.2	68	1.7	98
Maize	8.4	6.7	4.7	72	1.3	101
Rice	7.7	6.5	0.4	76	0.4	94
Wheat	12.0	9.6	1.7	67.5	1.2	98

Wheat

This is the most important of all the farinaceous seeds, and is extensively used all over the world. If a grain of wheat be cut and examined under the microscope the following may be distinguished :—

1. The germ or embyro forming about $1\frac{1}{2}$ per cent. of the entire grain.

2. The kernel or endosperm—forming about 85 per cent. of the grain, and consisting of two large masses of nutritive material.

3. The bran or the outer covering ; this is of darker colour than the interior, and composed mainly of cellulose and mineral matters, forming about 13.5 per cent. of the grain.

A grain of wheat, free from the husk, when ground between millstones and shifted is separable into *bran* and *flour*. Flour is divided into three portions · *Sooji* is the coarse grain derived from the outer coat of wheat and is the most nourishing ; *atta* is the next layer of finer grain ; and the fine white flour or *maida* is produced from innermost layer. Bran, however, is not devoid of nutriment, and the exclusion of it from the flour means some loss of mineral matters and some proteins from the aleurone cells.

Flour mixed up with water forms a tenacious mass commonly known as *dough*, from which macaroni, vermicelli, etc., are prepared. If on the other hand this dough be rubbed and washed with water on a fine sieve or muslin, there remains ultimately a white, sticky mass behind, and the washed fluid contains starch, which on being allowed to rest falls to the bottom. The sticky mass is called "gluten" and is the chief nitrogenous element of flour. The presence of gluten in wheat helps in the formation of bread, as it has sufficient coherence to remain spongy.

Flours are of different qualities according to their coarseness, the coarsest kind being known as *pollard* or *bran flour*. Wheat atta used for the preparation of different articles of food should always be fresh. Good flour should be white in colour without any smell or odour, silky to touch and not gritty. Fine white flour as prepared in mills is apt to cause constipation, and is of less nutritive value, and contains less mineral salts. Flour should be stored in godowns with high impervious floors.

It has often been said that "whole-meal" with all the constituents of the grain is more nutritive, but it should be noted that the bran-cells are hard and indigestible, and often irritate the intestinal canal. It is, however, of great value to people suffering from chronic constipation. In fact, with the exclusion of bran in fine white flour, about 15 per cent. of nitrogenous substances, 3.5 per cent. of fat, and 5.7 per cent of salts are lost. A "decorticated whole wheat meal" is now prepared where the outer or more indigestible layers of bran are separated from the highly nutritive inner tunic.

Preparations from Wheat Atta and Flour

Bread.—This is the chief product of wheat atta, and is made by converting flour into a firm and porous substance, ready for easy mastication, and while containing some water, is not moist or sticky.

Bread is prepared by first forming a dough and then imparting the necessary property of porosity, which is essential for easy digestion, either by generating within

its substance or by forming from without, carbonic acid gas. Generation of gas within the dough is effected by either of the following methods producing different varieties of bread.

(*a*) *Fermented Bread.*—When yeast is added to the dough fermentation ensues, CO_2 gas is generated and is entangled by the tenacious material which swells up into a spongy mass rendering it porous and light. If at this stage it is placed in an oven and baked, fermentation becomes arrested and the whole mass hardens up into a light and spongy substance commonly known as bread. The ferment generally used is yeast. When leaven is used the bread is known as *leavened bread.* Leaven is a portion of dough put aside from a previous baking in which fermentative action has reached an advanced stage of activity.

(*b*) *Unfermented Bread.*—Under this head is included such bread as is vesiculated by the use of baking powders for the evolution of CO_2 gas. Many forms of powders are in the market, but they all depend on the action of some alkaline carbonate, either soda or ammonia, with an acid as hydrochloric, tartaric, or citric. Although it serves the purpose very well, it appears that the less chemicals used for culinary purposes, the better.

(*c*) *Aerated Bread.*—When CO_2 instead of being generated by fermentation within the dough is separately prepared and incorporated with flour and water, aerated bread is produced. The advantages claimed for this method are :—

(*a*) It does away with fermentation and other chemical changes resulting therefrom.

(*b*) Its results are certain and uniform.

(*c*) It does away with the use of alum.

(*d*) It is absolutely clean and sanitary, as it requires no handling.

(*e*) The bread is said to keep sweet and good for a longer time than fermented bread.

A good bread contains about two-thirds of its volume of gas, and of the solid part about 45 per cent. consists of water.

It is said that baking increases the digestibility of bread, the nitrogenous constituents are changed, and the starch granules are ruptured. Well-baked bread should have a yellowish brown crust, should be uniform in texture, and be permeated by minute cavities, but without eyes or large air-cells. The colour of the crumb, except in whole-meal bread, should be white and the bread should be free from acidity and sourness. With some stomachs even the best fermented bread disagrees, and for them the aerated bread may be recommended.

Newly made bread is soft and tenacious, stale bread crumbles readily into separate particles. Being more palatable and sweet, new bread, however, is generally preferred to stale ones ; but it is less digestible, as it gets clogged together during mastication, and when swallowed reaches the stomach in non-porous lumps, and consequestly is not so easily acted upon by the saliva and the gastric juices. This is obviated by toasting, which renders the bread more friable and allows it to be more readily acted upon by the digestive juices. Toasts should be thin and crisp and eaten soon after they are made. Weight for weight, bread is one of the most nutritious of all our foods, and the fact that it is always eaten with butter, makes up for the deficiency of fat.

Certain substances are often used as adulterants in the preparation of bread, the chief being alum. It is used to make the bread look whiter, but it also helps in the formation of a good dough when the flour used is either old or produced from badly ripened grain. The presence of alum is detected by adding to the crumb a mixture of logwood and ammonia carbonate solution when a violet or blue tint is produced. But this test is unreliable when the bread is sour.

Chappaties.—These are non-aerated hand-made unleavened breads prepared by first making the dough and then spreading it over a smooth surface. They are of a circular shape and of thickness varying from that of a thick paper up to one-sixth of an inch. Chappaties are fried dry on a frying pan and then baked over fire. Prepared from good flour they are light and white, and when

properly baked they are blown out with air in the centre. During this process the starch granules swell and are made ready for easy digestion. Chappaties should always be eaten fresh and rejected when more than one day old, as they usually become hard and difficult to digest. As a rule they are eaten smeared with ghee, thus making up for the deficiency in fat. Chappaties contain 6.7 p.c. gross protein ; 5.0 p.c. available protein ; 1.0 p.c. available fat ; 47.5 p.c. available carbohydrate ; 1.2 p.c. mineral matter ; and yield for every ounce 64 calories. As compared to this bread yields gross protein 7.5 ; available protein 6.0 ; available fat 0.7 ; available carbohydrate 50.0 ; mineral matter 1.0.

From *Sooji* is prepared *Halowa* by cooking it with ghee, sugar, and water. It is highly nutritious, but not so easy of digestion, and often gives rise to acidity.

Rice

This is most widely cultivated in the East and forms the staple food of the Indians. In reality it is paddy deprived of the husk. Different varieties of rice are to be had in the market, but the principal ones are Burma and Country rice. Rangoon rice, or the so-called "*white rice,*" is prepared from the unhusked paddy which is milled by machinery, and the husk with the pericarp and the outer layer of the grains are subsequently removed, and consequently it is smaller in size than Country rice.

Country rice, on the other hand, is prepared by soaking the paddy in water for 30 to 40 hours, and then transferring it into covered jars or cylinders, where it is steamed for 5 to 10 minutes. It is finally removed and dried in the sun. This " parboiled " rice is then roughly husked, but a large amount of pericarp is still retained. It will be seen that in the preparation of Rangoon rice the grains are deprived to some extent of their outer layers, and consequently lose a certain amount of the important food accessory the *antineuritic vitamin.* Country rice, however, retains these outer layers, and, therefore,

the *vitamin.* Parboiling renders the rice grains tough, but portions of the pericarp still remain even after husking.

Composition of Rice.*

	Unpolished	Parboiled	Polished	Rice bran
Vitamin B	+	+	0	+++
Protein	9 %	7.68 %	6.5 %	Higher
Fats	1.65 %	2 to 2.5 %	0.25 to 0.5 %	22-24 %
Phosphorus	0.54 %	0.58 %	0.26 to 0.38 %	3.2 %
Protective outer coat	Present	Present	Absent	

Of all the cereals rice is poorest in protein, fat, and mineral matters. Its chief constituent is starch, and this exists in an extremely digestible form. About $2\frac{1}{2}$ oz. cooked by boiling require $3\frac{1}{2}$ hours for disposal by the stomach. But it should be noted that it is not the function of the stomach to digest carbohydrate. It only performs the mechanical part and prepares it and sends it on to the intestines for final disposal. In the intestines rice is very completely absorbed. Being insipid and only rich in starch, rice is as a rule eaten with condiments and other foods rich in nitrogenous substances, as pulses, fish, ghee, etc., to supply the deficiency in protein and fat.

Good rice should be entire, clean, and well-husked, and non-fermenting. It should not be mixed with any gravel or earth. It should preferably belong to the last harvest but one before, as new rice is apt to cause indigestion and diarrhœa. Rice which has been sown on swampy grounds and which has not been transplanted, and which comes to maturity at the close of the rainy season, frequently gives rise to gastro-intestinal troubles.

Rice should be stored in dry and well-ventilated rooms having impervious floors. When kept in hot and damp places, it ferments and becomes mouldy with production of toxins. Rice can be preserved by occasional

* After Greig, Fraser and Stanton.

exposure to the sun and by mixing lime with it. Active fermentation may be detected by putting the hand inside the bag of rice, when it will feel warm.

Rice under kept boils thick in the grain and is so gummy that the grains stick together, but when of good quality and condition the grains elongate remarkably by boiling; they do not stick together, and they have a pleasant mealiness in the mouth.

Rice is not infrequently tampered with by traders, and old and new rice, or rice of different qualities are often mixed together, and chalk powder and lime usually added to give it an uniform appearance.

Cooking of Rice.—Rice should be thoroughly washed in cold water before being cooked. Boiling is the common method of cooking, when the rice grains swell and become soft. These are then strained and the water thrown away. By the process of boiling, some of the proteins and mineral salts are lost. The more economical method of cooking rice is by steaming, as then the protein and salts are not dissolved out.

Partly boiled paddy keeps better and is probably more wholesome though less white in colour than ordinary raw table rice. New rice can be cooked in about half an hour while old rice takes almost double the time and keeps good for more than twenty-four hours after cooking.*

Khichri.—In this process rice and dal are boiled together to a thick consistency with the addition of ghee and condiments. In the preparation of khichri the water is not rejected. This is not only highly nutritious but palatable and appetising.

Barley.—This is very nutritious and is characterised by its richness in mineral matter. It is rich in nitrogenous matter, which exists in the form of casein and albumin, but the amount of gluten present is very small, and consequently barley meal is not so well suited for making bread.

The grains deprived of husk form *Scotch* or *Pot Barley*, but when all the integuments are removed and the grains

* McNally.

are rounded and polished, they form *Pearl Barley,* and when ground to powder they are sold as so-called *Patent Barley.* It is chiefly in the form of pearl or patent barley that it is used as human food.

Malt is barley in an incipient stage of germination.

Maize or **Indian Corn** (*Makkai*).—This ground to powder forms part of the diet in some parts of India and in certain Indian jails. It contains, according to McCay, 9.55 per cent. of protein, 66.20 per cent. of carbohydrate, 2.30 per cent. of fat, and 11.50 per cent. of water. It is deficient in gluten and does not form bread, but like oatmeal, when mixed with milk, eggs, and other flours, forms wholesome and nutritious puddings and cakes. As it contains a large amount of fatty or oily matter it is used for fattening animals. Maize protein, owing to its low biological value is said to produce *pellagra.*

Corn Flour is maize flour that has been deprived of its peculiar flavour by a weak solution of soda. It was formerly believed that *makkai* is less digestible than wheat atta, but recent investigations have proved that proteins of *makkai atta* are, under the same conditions, as well assimilated as those of wheat atta. 90 per cent. of its dry matter are absorbed as against 82 per cent. of wheat.

Oats.—These form a highly nutritious food, and though rich in nitrogenous principle they are not considered equal in nutritive value to wheat flour. Oats are deficient in gluten and, therefore, cannot be vesiculated and made into light bread. They are not so easily digested by those unaccustomed to their use. In the form of porridge, oatmeal is very widely used, and makes a nutritious and agreeable beverage in the form of gruel. With some, oatmeal gives rise to a certain amount of heating effect, which is said to be due not so much to the presence of nitrogenous substances as to a special substance to which the name " avenin " is given. This is not well suited to persons with a gouty diathesis as it increases the formation of uric acid.

II. PULSES

Pulses belong mostly to the leguminous order, and are richer in nitrogenous substances than any other vegetable food. This they owe to the presence of vegetable protein, commonly called legumin or vegetable casein. Pulses are used in India chiefly in the form of dals, of which there are many varieties, viz. *moong*, *mattar*, *arhar*, etc. Owing to their richness in protein pulses are sometimes called "Poor man's beef"; indeed for the large proportion of protein they contain pulses are used in conjunction with other foodstuffs rich in starch as rice. The nitrogenous ratio in the case of the pulses varies from 1 to 2 or 4. Pulses also contain salts of potash, lime, and sulphur. As compared with cereals, these are less easily digested, and are apt to produce a feeling of heaviness, and not infrequently give rise to much flatus. Galen said "they are harder to digest and give rise to bad dreams."

In the dried condition pulses have no antiscorbutic properties. If however the dried seeds are soaked in water and are allowed to germinate for a day or two they develop the antiscorbutic vitamin. They are rich in vitamins which prevent beri-beri. Most of these are taken cooked, and the green ones may be eaten raw. Lentils contain a large amount of nitrogenous substances and are rich in iron and phosphate of lime, and have the advantage over peas in not containing sulphur, and thus not giving rise to the objectionable hydrogen sulphide in the intestines. Khesari dal (*Lathyrus sativus*) gives rise to a train of symptoms when eaten for a long time, known as *Lathyriasis*. The symptoms are spastic paralysis of the lower limbs and muscles of the thigh with increased knee jerks. This is probably due to the production of certain poisonous amines in the *dal*. The disease is very common amongst the poor, who live chiefly on powdered khesari dal.

Pulses should be well washed and husked before cooking. In the absence of animal food, they are usually taken with rice, and being poor in fat they may with advantage be used with other fatty foods, *e.g.*, bacon

and peas, either boiled, or cooked with ghee or oil. They are rich in purin bodies, and should therefore be avoided by persons with a gouty diathesis.

The composition of common forms of pulses is given below :—

	Protein	C Hydrate	Fat	Water	Mineral matter.
Peas (green)	4.0	16.5	0.5	78.1	0.9
,, (dry)	21.0	61.4	1.8	13.0	2.60
Beans (dry)	25.5	56.4	1.7	13.1	3.3
Lentils	23.2	60.4	2.0	11.7	2.7
Kalai	22.58	58.02	1.10	10.87	3.61
Moong	23.62	53.45	2.69	10.87	3.57
Gram	19.94	51.13	4.31	10.07	[illegible]
Arhar	21.67	54.27	3.33	10.08	5.50
Mussur	25.47	55.03	3.00	10.23	3.33
Soy bean	32.9	33.1	18.1	11.0	4.9

When used as a source of antiscorbutic vitamin, the pulses should be entire and not husked or slit, otherwise they will die and germination will not take place. The peas or lentils should first be soaked in water for 24 hours, these absorb 100 p.c. of water and the process of germination commences, when the anti-scorbutic vitamin begins to appear. If however the germination is continued for 24 to 48 hours the amount of vitamin is considerably increased. This is done by pouring off the excess of water and allowing the seeds to remain damp with access of air. These germinated pulses may then be cooked. Boiling should not be prolonged beyond the time required for rendering them soft and palatable having regard to sensitiveness to high temperature of the anti-scorbutic vitamin.

III. ROOTS AND TUBERS

These may be regarded as reserves of nourishment for the use of the plant itself, chiefly in the form of starch ; protein and fat being practically absent. Tubers are largely used as food, but are much inferior to either cereals or pulses in nutritive value, containing as they do a relatively large amount of starch and very little protein. Of

the small amount of nitrogenous material a large proportion is in the form of amido bodies which have little or no nutritive value. These are, therefore, not suited to form the main part of any diet. Root tubers contain mineral matters, chiefly salts of potash, which give them a greater value as an article of diet than they would otherwise be entitled to possess.

Digestibility of root tubers depends largely upon the amount of cellulose, but, as a rule, they are very indifferently absorbed and are prone to derange the stomach and intestines, if consumed in large quantities.

Composition of some of the common forms of roots and tubers :—

	Water	Protein	C Hydrate.	Fat	Ash.	Extractives.
Potatoes	76.7	1.2	19.7	0.1	0.9	1.4
,, (boiled)	73.8	-	—			
Carrots ..	85.7	0.5	10.1	0.3	0.9	1.0
,, (cooked) .	93.4	0.53	4.47	0.17	0.14	
Turnips	90.3	0.9	6.8	0.15	0.8	1.1
,, (cooked)	97.25	0.32	1.67	0.06	0.32	.
Radish .	90.8	1.4	4.6	0.1	0.7	
Beetroot ..	83.0	0.5	14.0	0.1	0.9	1.0
Onions .	89.1	1.6	8.3	0.3	0.6	
Sweet Potatoes	72.9	1.6	? 4.3	0.5	0.7	

Potatoes

The potato is universally used as a wholesome, palatable, and popular article of food of much nutritive value. Opinions are at variance as to how far by itself the potato is capable of sustaining life and vigour for any length of time. On the other hand, potatoes supplemented by a small amount of some other food containing nitrogenous material, such as milk or fish, supply to a large number of people a diet containing all that is necessary to maintain health and strength.

The potato is a valuable antiscorbutic, chiefly due to the presence of antiscorbutic vitamin. Valuable and wholesome as the potato is, it is nevertheless unsuited for weak stomachs. In fact, this is one of the most common articles of food which the physician has to withhold from

his patients, and this is chiefly due to the large amount of starch that it contains. The digestibility of potatoes depends also on the form in which they are eaten.

During boiling the albuminous juices are coagulated, and the starch granules absorbing water swell up, and the cells in which they are contained break down, with the effect that the potato assumes a mealy or floury appearance. When mealy, the potato is easily digested, and new potatoes being less mealy are not so easily digested. Dry heat, as by baking, converts the starch into a soluble form and finally into dextrose.

Steaming is better than boiling, but the skin should not in either case be previously removed. The antiscorbutic vitamin is destroyed by prolonged heating. Potatoes boiled in their jackets are digested one hour earlier than when boiled without the skin; and most nutrition is obtained when thus boiled. About 46 p.c. of total nitrogen is lost when potatoes are first peeled and then boiled.

Sweet Potato.—It may be used in place of the ordinary potato. It is rich in starch (16 per cent.) and sugar (10 per cent.). When boiled it becomes very soft and forms a wholesome and useful food.

Arrowroot.—This is a preparation from the tuber of *Maranta arundinacea,* containing about 88 per cent. of pure starch. It forms a pure and simple starchy food of a bland unirritating character, valuable for invalids.

Sago and **Tapioca.**—Sago is obtained from the pith of *Sagus feriniferus.* The starch grains are large, irregular, with ill-defined concentric lines. Tapioca is also pure starch obtained from the tubers of *Manihot utilissima.*

Sago, arrowroot and tapioca are all agreeable and easily digestible forms of pure starchy food, used chiefly for invalid cookery. They are also used in the preparation of pudding, etc. Alone they have a very limited nutritive value, but may with advantage be added to either milk or soup, which are rich in proteins. They rank amongst the most completely absorbable of all foods.

Carrots, beetroot, radish, etc., are all roots of a succulent character, and are used as fresh vegetables. Beetroot is used mostly in salads and is often boiled.

EXAMINATION OF STARCHES

Place a drop of water on a clean glass slide and add a portion of the starch powder and mix. Put on a cover glass and examine under the microscope for—(1) shape, (2) size, and (3) presence or absence of hilum and striations.

The starch granules of potato and arrowroot are large and oval with well-marked concentric rings or striæ and a distinct hilum, which in potatoes is at the smaller end.

The outline of the starch granules of sago and tapioca is semi-faceted with a hilum and ill-defined rings.

IV. GREEN VEGETABLES

These have a very low nutritive value, and are used not so much for their nutritive principles as on account of the important alkaline salts which they contain. Most of the salts are eliminated as carbonate and may with advantage be used by presons with a tendency to gravel. Some give an agreeable flavour to the food and help digestion, and are useful as condiments. Fresh, green vegetables are rich in antiscorbutic vitamin. Cabbage and onion are about equally useful for the prevention of scurvy: while desiccated vegetables are almost useless for the prevention of experimental scurvy even when they are dried at low temperature (30° to 37°C.).

They form an agreeable diversity of our food and give relish to other foods. Green vegetables consist of leaves, buds, young shoots, leaf stalks, and often the entire plant. These contain a large amount of water (about 90 per cent.), and the nitrogenous material is very small (from 1 to 4 per cent.) and of this again about half only consists of protein. The deficiency of fat is often made up by cooking them in oil or ghee, and thus prepared they act as valuable vehicles for carrying fat into the system. Green vegetables are rich in cellulose which offers a resistance to the action of

digestive juices, but the indigestible residue in the intestines acts as a "ballast" and stimulates the intestinal action; consequently they are of great value in cases of chronic constipation. Vegetables should have the stalks and midribs removed before being prepared for food, and the cooking should be thoroughly performed to separate the fibres. It should be noted that the real nutritive value of fresh vegetables, which is very low becomes still less by cooking, and a large part of the remnant which reaches the intestines escapes absorption.

The following is a list of some of the commonly used vegetables :–

	Water.	Protein	Fat	C Hydrate	Mineral matter	Fuel.
Cabbage	89.6	1.8	0.4	6.9	1.3	165
Cauliflower	90.7	2.2	0.4	5.9	0.8	175
Tomatoes	91.3	0.9	0.4	3.9	0.5	105
Celery	94.5	1.1	0.4	3.3	1.0	85
Watercress	93.1	0.7	0.5	3.7	1.3	
Cucumber	95.4	0.8	0.2	3.1	0.5	80
Asparagus	94.0	1.8	0.2	3.3	0.7	105
Lady's finger	90.4	1.96	1.4	5.72	0.8	
Brinjals	93.98	0.89	0.94	3.48	0.26	
Plantain or Banana	75.3	1.3	0.6	22.0	0.8	160
Red gourd	93.10	0.90	1.0	3.96	0.7	

From the above it is evident that most of the vegetables contain a very small proportion of carbohydrate, and so they may be used in cases of diabetes, especially as carriers of fat. Asparagus has a diuretic effect, and imparts a peculiar odour to the urine due to a volatile sulphur compound produced from it in the intestine (Hutchison). Onions, garlic, and many of the lily tribe are used chiefly as condiments for flavouring food. The volatile oil present is excreted with the various excretions, and imparts its characteristic odour to the breath, urine, etc.

Cauliflower is more easily digested than any other form of vegetable and may be used for dyspeptics. Cucumber is very indigestible, but its agreeable flavour and cooling properties have given it a great popularity. When young it is often eaten raw with salt, or as salad with vinegar, lemon juice, salt and pepper.

V. FRUITS AND NUTS

From the nutritive point of view, fruits are divided by Hutchison into "Food Fruits" and "Flavour Fruits." The latter are used chiefly for the sake of sweetness and flavour. Like fresh vegetables fruits are of use by reason of the important mineral salts they contain, which exist chiefly in the form of salts of potash combined with vegetable acids. The nutritive value of fruits depends on the presence of carbohydrate, which exists in the form of sugar, and is commonly known as *levulose* or fruit sugar.

The difference in all fruits as regards the digestibility depends on the nature of the fruit and the degree of ripeness. Certain chemical changes take place during the process of ripening. As the process begins, the fruits cease to grow, absorb carbon and give off oxygen, acids and astringent substances become less, and the starch is converted into sugar. Excess of acids present in the unripe condition often irritate the bowels, and may set up diarrhœa and colic.

Fruits which afford the most nutriment are the banana, date, fig, grape, mango, etc. This is due to the large proportion of sugar which they contain. The antiscorbutic property is possessed by certain fruits which are rich in potash salts, lime and magnesia, *e.g.* apples, lemons and oranges. Fruit eating lessens the acidity of the urine or even may render it alkaline, owing to decomposition of various alkaline salts in the blood or tissues which are converted into alkaline carbonates and excreted as such.

Grapes are of great value and their use is directed to various purposes. The juice of the ripe grapes contains grape sugar, bitartrate of potash, tartrate of lime, malic acid and water but the amount varies with different varieties. Grapes are largely used as food, and are among the most agreeable, wholesome, and nutritious of all fruits. Being refreshing and cooling they may be taken by invalids, but the skins and the seeds should always be thrown away, for they are apt to set up irritation of the bowels.

Dried grapes are called *raisins*, and contain more sugar and less acid and are less digestible. With milk they are often taken as gentle laxatives.

The **plantain** or **banana** belongs to the class of *food fruits*. These are most extensively cultivated in India. The fruits grow in clusters, and each cluster often contains about two hundred fruits and may weigh from 40 to 60 lbs.

Plantains are largely eaten in India both when green and ripe. The ripe plantain forms an agreeable and delicious fruit, and is often used as dessert. The skin is rather thick and may easily be stripped off when ripe, and the edible portion is soft and spongy, rich in saccharine and nutritive matter. It contains a relatively high percentage of nitrogen, nearly 5 parts per hundred of the entire fruit, or one-fifth of the total solids. In the unripe state, when cooked, it is used as a nutritive article of food with other vegetables. Dried and ground to powder it constitutes what is called *plantain meal* or *banana flour*. This is used as a nutritive food especially suited for invalids. It contains proteins 4.0 per cent., fat 0.5 per cent., carbohydrate 80.0 per cent., mineral matter 2.5 per cent., and water 13.0 per cent. The finest banana flour, called "*bananose*," at the end of one and a half hour of pancreatic digestion develops twice as much sugar as the same quantity of oatmeal. Made into a thin gruel with water or milk it constitutes a highly nutritious article of diet.

"Bael," either fresh or in the form of sherbet, preserves or dietetic bael powder, is very useful in dysentery, and forms a cooling and agreeable drink in hot weather. It also acts as a mild laxative

The mango is one of the most highly prized of all fruits. It is palatable and nutritive. When unripe, it is used to make pickles, tarts and preserves, and sweetened with sugar it is made into "chutney." When ripe it is wholesome and agreeable, and is extensively used in India. Mangoes cause looseness of the bowels and should not be eaten when there is diarrhœa. Dried mango slices are known by the name of *Amchur*, and are said to be of use in scurvy.

Oranges are an exceedingly useful article of diet especially for invalids. The fresh juice allays thirst, and is well borne in cases with much gastric irritation. Orange juice is a mild laxative for infants, and is the best remedy for infantile scurvy.

Pineapples are very common in India. They are very wholesome, and the juice of ripe fruits contains a ferment capable of digesting proteins. Three ounces of the juice will dissolve 10 to 15 grs. of dried albumin in four hours.

In addition to the above, melons, cucumbers, apples, apricots, etc., are all used and form delicate fruits for the table.

Nuts differ from the above fruits in that they possess higher nutritive value, but are not so easily digested, not that they are rich in fat but that they contain much cellulose. In fact the real nutritive value of nuts is so great that they can very well replace meat.

Cocoanuts, walnuts, almonds, etc., are very widely eaten in India. Nuts contain less carbohydrate, and are better suited for diabetics. Cocoanut water is cooling and refrigerant, and is a very useful drink during fatigue and thirst. The milk obtained from the ripe kernel by scraping and expression is rich in fat and protein. The kernel is a valuable food and is utilised in the preparation of different kinds of Indian delicacies.

	Gross protein	Available protein	Av. Fat.	Available C. Hydrate	Mineral Salts.	Calorie per oz.
Apples	0.3	0.2	0.3	10.5	0.3	13
Banana	0.8	0.6	0.42	11.2	0.7	19.2
Cucumbar	0.8	0.6	0.2	3.0	0.5	4.8
Figs	1.1	1.1	--	17.0	0.6	22
Grapes	1.0	0.8	1.0	14.1	0.5	21
Apricots	1.0	0.8	0.5	12.0	0.4	18
Water melons	0.2	0.15	0.1	2.7	0.2	3.8

Fruits are laxatives and valuable antiscorbutics due to the presence of antiscorbutic vitamin. Oranges, grapes, lemons, papaya, etc., are valuable in this respect. Papaya also helps the digestion of proteins, for which purpose green papaya is often used.

Fresh fruit juices appear to be among the most valuable of the antiscorbutic materials. When they are preserved their value as such is doubtful. Thus it was found that lime juice issued in Mesopotamia up to the end of 1916 had no antiscorbutic value, which arrived there after a long journey overseas and was probably over six months or more old when issued. It appears that the antiscorbutic vitamin gradually disappears on keeping.

The preservation of fruits is often resorted to and this is done by means of syrups, and keeping them in hermetically sealed cans.

Sugar

Sugar is obtained from the sugar-cane, beetroot, maple tree, date palm, etc. It contains about 94 per cent. of saccharose and about 2 per cent. of water. Good sugar should be of white colour, crystalline, not moist to the touch and soluble in water. Unpurified sugars contain nitrogenous matters which on decomposition ferment. It is used as a sweetening agent and enters largely in the preparation of delicacies, syrups, etc.

Honey

Honey consists of the saccharine substance collected by bees from the nectaries of flowers and deposited in the cells of the honeycomb. Honey differs from ordinary sugar in containing more dextrose and levulose than saccharose. It is largely adulterated with glucose, starch, and cane sugar, and imitated by adding a piece of genuine honeycomb to a jar of glucose syrup. Under the microscope pollen grains will always be found present in genuine honey.

CHAPTER X

ANIMAL FOODS

MEAT consists of muscle fibres held together by connective tissue. The fibres contain muscle plasma or muscle juice, and this is made up of water holding in solution nitrogenous substances, salts, and extractives. The salts are chiefly chlorides and phosphate of potash. About 15 per cent. of ordinary butcher's meat is inedible, being made up of cartilage, tendon, etc.

The **proteins** of meat are myosin, muscle albumin, and hæmoglobin. *Rigor mortis* is due to the clotting of myosin, which makes the meat tough. But acids are very soon developed in such a meat which soften the myosin, and make the meat more tender and give it a better flavour. Meat should therefore be eaten after rigor mortis has passed away.

The *connective tissue* of meat yields gelatin on boiling; this is aided by the acids developed in meat on hanging, and this gelatinisation is the result of conversion of cholagen. The acids which are developed later improve the flavour of the meat, but these are present even at the time of death of animals which have undergone great muscular exertion before death. Hence the flesh of hunted animals is of superior value.

Connective tissues are more abundant in old animals than in young ones, consequently the meat of old animals is tough and requires more cooking.

Fat is often imbedded in the connective tissues, but the amount varies in different animals. In pork the fat is in excess, whilst in chicken it is almost absent. Fat so placed hinders digestion and absorption of meat. But the fatter the meat the poorer it is in water; in other words, fat replaces water but not the proteins.

Extractives are substances contained in solution in the meat juice. The real chemical composition of the extractives is not well understood. They have none of the nutritive value of meat, but are of use in giving the peculiar flavour and taste.

The percentage composition of the important animal foods used in the tropics is given below :—

	Protein.	Fat.	Carbohydrate	Salt.	Water.
Beef (average)	20.96	5.41		1.14	72.03
Mutton	17.11	5.77	..	1.33	75.99
Fowl (lean)	19.72	1.12	..	1.37	76.22
Fish	16.0	5.0		1.0	78.0
Milk (cow)	4.20	3.70	4.50	0.7	86.0
Cheese (Dutch)	28.21	27.83	2.50	4.86	36.60
Eggs	12.55	12.11	0.53	1.12	73.47
Butter fresh ..	2.00	85.00	..	1.00	12.95

Inspection of Animals

Animals must be kept under observation in a stock yard or cattle mart for at least 24 hours, preferably longer, before being slaughtered. During this period they must be fed and watered. They should not be too old nor too young. The composition, flavour, digestibility, etc., of meat differs with the species, age, sex, and part of the body. A good ox should weigh between 600 and 1200 lbs. and be from 2 to 8 years of age. In India a gram-fed sheep weighs about 35 lbs. and yields about 18 lbs. of food, and an ordinary country sheep weighs about 25 lbs. The weight of an animal in pounds can be determined by the following formula :—

$$\tfrac{2}{3}\,(5L \times G^2).$$

L = the length of the trunk from front of the scapulæ to the root of the tail.

G = the girth of circumference just behind the scapulæ.

Add to the weight thus obtained $\frac{1}{20}$th of the weight for very fat animals, and deduct the same amount for very lean ones.

The animal is divided into carcase and offal ; the former includes the whole of the skeleton with the excep-

tion of the head and feet, with the flesh, membranes, vessels, and fat as well as the kidneys and fat surrounding them; while the latter includes the head, feet, skin, and all the internal organs except the kidneys. Sixty per cent. of the total weight of an animal can be utilised as food, and five per cent. more in the case of fat animals.

The age of an animal can approximately be determined from the teeth and the rings on the horns, but the dealers often file the horns.

A healthy animal should be well nourished, its skin supple and its muscles fairly firm and elastic. It should not shiver or show any sign of pain, and should move about freely. When lying down it should be able to get up with ease. The other indications of health are: quick bright eyes, nostrils red, bright and moist, tongue not protruding, respiration regular and easy with no foul odour in the breath, circulation tranquil, skin glossy and smooth, and excreta normal.

When diseased the hairs stand out and are not smooth, the nostrils are dry and covered with frothy exeretions, the eyes heavy, the tongue furred and hanging out of the mouth, respiration difficult and movements slow. In febrile conditions the ears and feet, and in milch cows teats, are hot.

Of the infectious diseases the most important are pleuropneumonia, cattle-plague, swine fever, actinomycosis, foot and mouth disease, anthrax, and tuberculosis.

Inspection of Meat.—Meat should in the tropics be inspected soon after the animal is slaughtered. It takes about 24 hours for the carcase to thoroughly 'set' after slaughtering; but this varies with the temperature, moisture, etc. It should show no signs of bruises or bile stains. The fresh and good meat should not show any pitting or crackling and should be firm and elastic to the touch, of good colour throughout but not dark, red, livid, mahogny or very pale. The colour of the fat varies from white to yellow. A knife plunged into the meat and withdrawn should smell sweet in good meat. The juice should be reddish and acid, alkalinity is a sign of decomposition.

Of greatest value to the inspectors is the interior of the chest. In healthy animals these are perfectly smooth and the ribs with the intercostal muscles are clearly visible. If the inside is rough and the lining membranes cloudy it indicates the animal had suffered from an inflammatory affection. The lungs should be spongy, of a bright pink colour and a small peice should float on water. They should be free from cavities, nodules, pus, etc. The liver should be dark brown in colour and sufficiently hard not to break easily on pressure. Alimentary canal should be free from any appearance of inflammation and should not smell of drugs.

Characters of good Meat.—The following are the characteristics given by Dr. Letheby in his "Lectures on Food":

1. It is neither of pale pink colour nor of a deep purple tint, for the former is the sign of disease, and the latter indicates that the animal has not been slaughtered, but has died with the blood in it, or has suffered from acute fever.

2. It has a marbled appearance, from the ramification of little veins of fat among the muscles.

3. It should be firm and elastic to the touch, and should scarcely moisten the fingers; bad meat being wet, sodden, and flabby, with the fat looking like jelly or wet parchment.

4. It should have little or no odour, and the odour should not be disagreeable, for diseased meat has a sickly, cadaverous smell, and sometimes a smell of physic. This is very discoverable when the meat is chopped up and drenched with warm water.

5. It should not shrink or waste much in cooking.

6. It should not run to water, or become very wet on standing for a day or so; but should, on the contrary, be dry upon the surface.

7. When dried at a temperature of 212° or thereabouts, it should not lose more than 70 to 75 per cent. of its weight, whereas bad meat will lose as much as 80 per cent.

When meat is commencing to putrefy it becomes pale, moist, doughy, smells sickly and offensive, and gradually

turns greenish. The cellular tissue between the muscles softens and they are easily torn when stretched.

Cysticerci cellulosæ and *Trichina spiralis* are found in the muscles. To find out trichina a thin section of the muscle should be placed in liquor potassæ for a few minutes till it becomes translucent, when the coiled embryo will be seen inside its capsule.

Diseases produced by Unwholesome Meat.— Good meat decomposes readily in the tropics. It is advisable, therefore, that it should not be kept long but cooked and eaten the same day the animal is killed. Particular care should be taken for the proper storage of meat, which should be protected from flies, cockroaches, and other insects.

Meat, if decomposed, irritates the gastro-intestinal canal and gives rise to symptoms of ptomaine poisoning, viz., nausea, vomiting, abdominal pain, diarrhœa, severe prostration and collapse. Urticarial and erythematous rashes very often develop, or there may be fever and delirium. By cooking the microbes are destroyed, but the symptoms of poisoning are due to the products of decomposition —the toxins, and it is now believed that poisoning by meat is due to infective organisms (*B. enteritidis*) and their toxins. With the exception of tuberculosis and anthrax, meat is not likely to convey any infective disease. *Tinned meats*, etc., often contain sporing organisms of the *B. subtilis* and *mesentericus* groups. Para-typhoid bacilli are also occasionally the pathogenic agents in cases of "food poisoning" with gastro-enteritis, particularly *B. suipestifer*. A severe outbreak of food poisoning occurred in 1922 at Lock Muree. The causative organism being *B. botulinus* conveyed by eating potted food kept in sealed jars. Meat kept in a dark, damp, and ill-ventilated room with access of sewer gas, may develop posionous properties. Similarly meat of animals killed by arsenic or other poisons may produce toxic symptoms.

The flesh of animals suffering from such diseases as anthrax, rabies, glanders, general tuberculosis, etc., should be condemned with those killed by accidents and

lightning. The flesh of pigs infected with *Cysticerci cellulosæ* and *Trichina spiralis* should be avoided. *Distomum hepaticum* is very common in the sheep of India.

In investigating a case of food poisoning first make a note of every article of food that has been taken by the members of the affected family. Then determine by a process of exclusion the particular articles of food that have been consumed by the sufferers in common. These articles must be traced and secured, and the validity of the finding should be confirmed by feeding experiments on any of the lower animals.

Tuberculosis in Animals.—Cattle, pigs, poultry, and rarely sheep suffer from this disease. The Local Government Board in England have adopted the following recommendations of the Royal Commission on Tuberculosis as a guide to Meat Inspectors in the inspection of tuberculous carcases of cattle :—

(*a*) When there is miliary tuberculosis of both lungs. (*b*) When tuberculous lesions are present on the pleura and peritoneum. (*c*) When tuberculous lesions are present in the muscular system or in the lymphatic glands embedded in or between the muscles. (*d*) When tuberculous lesions are present in any part of an emaciated carcase.	The entire carcase and all the organs may be seized.
(*a*) When the lesions are confined to the lungs and the thoracic lymphatic glands. (*b*) When the lesions are confined to the liver. (*c*) When the lesions are confined to the pharyngeal lymphatic glands. (*d*) When the lesions are confined to any combination of the foregoing, but are collectively small in extent.	The carcase, if otherwise healthy, shall not be condemned, but every part of it containing tuberculous lesions shall be seized.

Preservation of Meat.—Meat is preserved by first cooking and then keeping in sterilised and hermetically sealed tins. Uncooked meat is preserved by:

(i) Drying, which is done by cutting up the meat in strips and exposing it to sun and air.

(ii) Smoking.

(iii) Refrigeration.

(iv) Freezing.

(v) Preservatives.—The most commonly used preservatives are either antiseptics or ordinary coarse salt. Boracic acid, salicylic acid, formalin are the antiseptics generally used. Their careless use is attended with the greatest danger to consumers and should therefore be forbidden.

The utility of applying heat or cold for this purpose is thoroughly appreciated. By these processes meat is preserved without addition of anything likely to be injurious. Heat is applied in the preservation of tinned meat, the high temperature destroys all germs and spores. In a refrigerator meat is often preserved in a raw state at a temperature of 1° C., but it must be cooked a few hours after removal. The cold does not affect the freshness or nutritive value of meat in any way.

Cooking of Meat.—This is done for the purpose of developing the flavour and improving the appearance of meat by destroying its colouring-matter. It sterilises the meat and lessens the risk of infection by any pathogenic germs or other parasites which may be present. It diminishes the amount of water even when meat is boiled. The connective tissue must as far as possible be converted into gelatin, but meat being a bad conductor, the heat must be applied slowly and the process consequently must be prolonged. Part of the extractive matters are removed by cooking, and this occurs to a certain extent even in process of roasting. The preservation of the extractive matter to which it owes its flavour is achieved by putting the meat in boiling water, which coagulates the outside layer, and prevents the escape of the flavouring ingredients as far as possible. The extractives are the chief constituents of soup, which has little or no nutritive value and yields no potential energy, although it seems

to relieve a feeling of fatigue. As it tastes and smells agreeably, soup aids digestion and is useful in the beginning of a meal.

Digestibility of Meat.—Both the mechanical and the chemical part of digestion is performed by the stomach, and thereby the chief nutritive constituent of meat (protein) is rendered fit for absorption. During the process of digestion the fibres swell up and become soft, they change their colour, and the whole mass becomes pulpy. These changes depend on a variety of circumstances, according as the fibres are harder or denser, and thicker or longer. Cooking has some influence on digestion, and Jessen has found that beef disappears from the stomach at different times depending on the method of cooking, thus :—

Raw beef	2 hours
Half boiled	$2\frac{1}{2}$,,
Wholly boiled	3 ,,
Half roasted	3 ,,
Wholly roasted	4 ,,

Common Forms of Meat

Beef.—It is very extensively used, being cheaper than mutton. But the flesh varies in quality, and according to the part used ; rump, sirloin, and fore ribs being considered the best. Beef is more strengthening, but requires strong digestive powers.

Mutton.—This is more easy of digestion and is widely used in India. Its fibres are shorter and more tender, but it contains a larger proportion of fat than beef does, and is consequently not suited for invalids. According to Jessen $3\frac{1}{2}$ oz. of raw mutton are digested in the same time as an equal weight of beef. The flavour and digestibility often depend upon the breed of the sheep, and their pasturage.

Pig.—This is comparatively less used in India as the Hindus, Mahomedans, and Jews do not take it. On account of the large quantity of fat it contains, pork is the most difficult of all meats to digest ; $3\frac{1}{2}$ oz. requiring 3 hours for digestion as against 2 hours for beef. Bacon is

more digestible as the fat is in a more granular form. Like all fat meat, pig contains less water. It is usually taken boiled with other lean meats like turkey, chicken, veal, or with eggs and vegetables like peas, beans, etc. The pig is liable to be affected with *cysticercus* of Tænia solium forming "measles," and this measly pork gives rise to a form of tape-worm—T. Solium. It is further affected with *Trichina spiralis*, causing the disease known as "trichinosis."

In the tropics generally the pig is a foul feeder and scavenger, and hence is considered not suitable for food. Its flesh is known at times to have produced intestinal disturbances. The Chinese are very fond of pork, but they generally cook it well (Simpson).

Goat.—This is largely used in India, especially by the Hindus. Its fibres are shorter, more tender than either beef or mutton, and contain less fat, consequently goat flesh is more easily digested. Goat is immune to tubercular diseases.

Poultry and Game.—These are very favourite forms of food; but in general aspect the flesh differs from that of ruminating animals. The flesh of birds differs from that of mammals in not being permeated by fat, consequently it is easily digested. The food on which these birds are fed makes a great difference in the character of the flesh. The flesh of the fowl, guinea fowl, turkey, and partrige is white, tender, of delicate flavour, and easy of digestion: the flesh of ducks and geese is darker, and is well known to disagree with delicate stomach. Game birds contain less fat than poultry. Of game birds there are many varieties in all parts of India, and these are largely employed and esteemed as wholesome and delicate food. Partridge, snipe, quail, pigeon, wild fowl, etc., have distinctive characteristics of their own.

Fish

Fish forms an important part in the ordinary food-supply of India. It has a very high nutritive value, though not so stimulating as meat, but in general it is less

rich in fat than ordinary meat. The flesh of many fishes has a peculiar odour, and different kinds vary greatly in their nutritive value, quality, and digestibility. There are two classes of fish, *fat* and *lean*. Those that contain less than 2 per cent. of fat are known as lean fish ; " Kai " or climbing perch (*Anabas scandens*), and " Magur," belong to this group. Those containing 2 to 5 per cent. of fat are grouped as fat fish ; " Hilsa " or Indian Herrings, and " Topsi " or mango fish, belong to this class.

Fish is poorer in extractives and therefore less stimulating than meat, but as it is digested more rapidly it is especially suited for invalid food, where stronger kinds of animal food are not so well digested. *Lean fish* is easy of digestion as the fibres are shorter and there is a comparative absence of fat. *Fat fish*, on the other hand, is very difficult to digest, and the oil is apt to get rancid and cause irritation of the stomach. Dried or salted fish is less readily digested than fresh ones, and the larger fishes less than the smaller or younger ones. According to Chittenden and Cummins the digestibility of fish in general is less than beef.

Absorption of fish takes place like meat, about 95 per cent. of total solids, 97 per cent. of protein, and 90 per cent. of fat entering the blood, so that fish ranks amongst the most fully absorbed of all foods.

It is popularly believed that fish is a valuable brain food owing to the excess of phosphates that it contains. Many authorities doubt this statement, and are of opinion that this depends more upon the ready digestibility by persons of sedentary habits than on any other factor, and that there is no justification for the statement that fish is rich in phosphorus.

As a source of energy, its value depends on the amount of fat it contains, fat fish being equal in this respect almost to moderately fat meat. As a source of building material, fish is inferior to meat as it contains less protein. The belief that fish possesses aphrodisiac properties is a mistake ; in fact, there is no evidence in its favour, on the other hand some authorities have pointed out that maritime populations are not especially prolific (Hutchison).

Shell Fish.—Allied to fish are lobsters, crabs, shrimps, prawns, and oysters, and they are very popular as articles of diet. These have high nutritive properties, but are less digestible. Sometimes, however, they produce symptoms of a poisonous or irritating nature, such as nausea, vomiting, diarrhœa, giddiness, etc., and frequently an erythematous rash. As mentioned before oysters when eaten raw are more easily digested than when cooked. The universal custom of adding vinegar, pepper, salt, onions, etc., stimulates the secretion of gastric juice and aids digestion.

Inspection of Fish.—Fresh fish is firm, stiff and elastic to the touch, and if held by the hand the tail should not droop. The condition of fresh fish should be always in a state of rigor mortis, *i.e.*, should not be soft or pulpy. The eyes should be clear and bright and not dull or sunken. The gills should be bright red and not muddy, pale, or discoloured. If decomposition sets in the body becomes flaccid. The skin should be intact and the scales not easily detachable in a sound fish. Soon after death the blood of fish coagulates ; when decomposition begins, the blood, on cutting the fish, will run out as a dull red liquid of an offensive odour. If on removing the bones a dull red mark at the points where they touched the flesh is noted it indicates that decomposition is well advanced. Mussles and oysters become unfit for food very soon after death.

To avoid rapid decomposition fish should be cut and eviscerated soon after being caught. It may be sent to distant places packed in ice.

Many parasites live in fish, but only one, *Bothriocephalus latus*, can be conveyed to man.

Poisoning by fish sometimes occurs, giving rise to symptoms of ptomaine poisoning. Oysters frequently give rise to an urticarial rash and when taken from sewage-contaminated water may carry cholera or typhoid infection. In certain seasons, especially during spawning, the fish ceases to be wholesome and acquires poisonous properties. According to Simpson Indian mackerel and sardines on the Malabar coast are sometimes poisonous,

and often the Bombay oyster causes serious illness when taken out of season, or when not absolutely fresh. Fish in any stage of decomposition should be condemned, as every hour adds to the degree of putrefaction.

Dried Fish.—It is unwholesome as it is often in a state of putridity, and when stored acts as a source of nuisance to the neighbourhood, as the smell arising from it is offensive and sickening.

Tinned Meat and Fish.—This is often dangerous in tropical climates, for it not infrequently gives rise to symptoms of poisoning of a very serious nature. If required, it should be bought from well reputed and respectable firms that do not deal in old stocks. They should be eaten within two months of their importation to India as decomposition usually starts after this period. Provisions imported between the months of March and October should be avoided, as the hot voyage deteriorates their quality.

When making a purchase see that the tin is new, clean, not indented, and that no fluid is leaking out. If decomposition sets in, the putrefactive gases will cause the two ends of the tin to bulge out. Fraudulent dealers let out this gas by making a hole, and solder it up again. This is detected by the presence of two soldered holes.

If on making an opening the liquid contents spirt out it indicates that putrefaction has commenced; if, on the other hand, the outside air is sucked in with a hissing sound, the contents are sound, and fit for human consumption. On opening the tin the whole of the contents should be taken out at once. The processs of drying, salting, pickling and smoking are commonly employed for preserving fishes. At any rate these are unfit for dyspeptics or invalids. Sardines, salmons, herrings, oysters, etc., are extensively imported into India; of these sardines, owing to the amount of oil contained in the tin, are less likely to cause ptomaine poisoning and are much better than other freshly packed tinned fishes, especially salmon.

Cooking of Fish.—This depends upon the kind of fish used. Oily fishes are best boiled, and this makes them more wholesome. Frying in oil is the common practice

with the Indians. The secret of frying consists in sudden exposure of the fish to a very high temperature, which has the effect of coagulating the porteins on the surface; and any escape of soluble substances is thus prevented. Cooking of fish should be avoided on either brass or copper vessels. Where copper vessels are used they are usually tinned inside, commonly known as "kalai," but this should be always of tin and not an alloy of tin and lead. Aluminium and iron vessels are better and less dangerous than copper ones, for in the presence of acids like vinegar, lemon, etc., copper forms a compound, acetate of copper, which is a powerful gastro-intestinal irritant, whereas with aluminium it forms alum, which is simply astringent, and, therefore, harmless.

Eggs

The egg is a typical example of food containing all the proximate principles necessary for the growth and development of the body. It is however deficient as regards carbohydrates. An ordinary hen's egg weighs about $1\frac{3}{4}$ ounces; of this about 12 per cent. consists of shell, 58 per cent. of white, and 30 per cent. of yolk. The shell consists of carbonate of lime, and the white with the yolk consists principally of nitrogenous elements. The white is made up of a solution of various proteins, the chief being egg-albumin. The yolk contains a large quantity of fat and a considerable proportion of lecithin, a phospho-protein called vitellin, and organic compounds of phosphorus and iron. The yolk contains less albuminous matter and does not so readily solidify with heat, and as it contains large quantity of oily matter floats in the white.

The comparative analysis of a hen's egg is as follows:—

	Water.	Protein	Fat	Other non-nitrogenous matter	Mineral matter.
White..	85.7	12 6	0 25		0.59
Yolk ..	50,9	16.2	31 75	0,13	1,09

The absorption of eggs in the intestines is almost complete, only 5 per cent. of residue being left. The value of one egg as food is equal to half a tumbler of milk, and the potential energy yielded amounts to 70 calories.

It is a known fact that mineral matters are more readily absorbed when they exist in organic combination. Hence iron in the yolk of eggs is absorbed very easily. Yolk of egg is therefore a valuable food for anæmic patients. It is also very rich in calcium ; in fact, except milk, no food contains so much lime salts in such an assimilable form. The yolk is rich in *antineuritic* and *antirachitic vitamins.*

The digestibility of eggs depends upon the form in which they are eaten. Raw eggs are not all digested in the stomach : this is perhaps due to the fact that being bland they hardly excite gastric secretion. The following table from Hutchison shows the length of time eggs remain in the stomach under different conditions of cooking :—

2 eggs lightly boiled	.. .. ..	$1\frac{3}{4}$ hours.
2 eggs raw	.. ..	2 ,,
2 eggs hard boiled	.. .. ..	3 ,,
2 egg omlette	.. ..	3 ,,

If hard-boiled eggs be finely divided and masticated they can be disposed of as easily as soft-boiled eggs. If the absorption of eggs from the intestine is delayed, decomposition ensues with production of H_2S and ammonia.

Eggs are preserved for a long time by preventing the entrance of the air through the pores, either by packing in saw-dust or salt, or by thoroughly smearing the shell with gum, butter, lard and oil, or by placing in lime water to which a little cream of tartar has been added.

Decomposed eggs are detected by placing them in a salt solution (about 2 oz. of salt in a pint of water) when they float. Fresh eggs are always heavier than stale ones. Hold an egg before a candle or a light, if fresh, it is translucent in the centre ; if stale, at the poles.

Milk

Milk is an ideal food, and is the chief diet for children up to the age of 18 months. It is in reality an emulsion of fat containing proteins, salts, and carbohydrates held in solution in water. The average percentage composition of various kinds of milk commonly used by man is given in the following table :—

Kind of milk.	Protein.	Fat.	Carbohydrate	Salts.	Water.
Human	2.97	2.90	5.87	0.16	88.0
Cow	4.9	3.7	4.8	0.7	86.8
Buffalo ..	4.4	9.0	4.8	0.8	88.0
Ass .	1.79	1.02	5.50	0.42	91.17
Goat	3.62	4.20	4.0	0.56	87.54

In milk we have the different classes of alimentary principles necessary for health, but the relative proportions are not so well suited for adults under normal conditions, an excessive amount of water and albuminoids inducing too active metabolism.

During digestion the gastric juice curdles the milk ; the curdling is due to the change brought about in the casein by rennin. The milk becomes at first jelly-like, but the curd shrinks and a yellow fluid called whey is squeezed out. The curd consists of casein and entangled fat or cream, while the sugar, the soluble albumins and other salts, remain dissolved in the whey. The casein of cow's milk forms dense and hard curd, whereas the coagula of human and ass's milk are softer and flocculent. The curds later on are changed into albumoses and peptones by the digestive ferments.

The density of the clot which the milk forms in the stomach depends on

(*a*) the amount of casein in the milk,
(*b*) the degree of acidity in the stomach,
(*c*) the quantity of lime salt present.

All these factors are affected by dilution, and for this purpose plain water, or better still, barley or lime water, may be used. The lime water, besides being alkaline, has a specific power in preventing clotting. Citrate of soda

prevents coagulation of milk by converting soluble lime salts into insoluble calcium citrate. Aeration by the use of sparklets is an important factor in avoiding clotting.

The *proteins* of milk constitute about 3 per cent. of the total weight; they are *caseinogen* and *lactalbumin*, and they are present in the proportion of 1 of casein, and 1·7 part of lactalbumin in cows' milk. Caseinogen is a phosphoprotein, and differs from albumin in not being coagulated by heat. It is, however, readily coagulated by weak acids and rennet. Casein is kept in solution along with phosphate of lime.

The chief *mineral matter* of milk is phosphate of calcium (which occurs partly in combination with citric acid and the rest as phosphates); sodium and potassium chlorides, magnesium phosphate and a very small quantity of iron are also present. Stockman has shown that 5 pints of milk are required to supply the necessary amount of iron for an adult every day.

The *fat* of milk is suspended in the albuminous fluid in very minute particles in the form of an emulsion, and constitutes about 3½ to 4 per cent. of the total weight. When milk is allowed to stand for some time the fat rises to the top as cream. Good milk contains about 8 to 12 per cent. of cream. The separation of cream is hastened by addition of water. The cream is best estimated by allowing 100 c.c. of the milk to stand in a graduated tube for twenty-four hours, and then reading off the proportion of cream, which should be on an average 8 per cent. Skimmed milk, from which the cream has been removed, contains about 1 per cent. of fat, and is not of much value for healthy people, but is better adapted for weak stomachs. As it contains all the nitrogenous elements it is far more nutritious than whey.

The *carbohydrate* of milk is lactose or milk sugar, it is slightly sweet but extremely hard and gritty. This is present from to 4 to 5 per cent. It remains dissolved in the fluid after casein and the fat globules have been separated. It is not prone to alcoholic fermentation, but when it is exposed to the air for some time and especially if it be warm, certain chemical changes take place, and part of

the lactose is converted into lactic acid ; this acid combines with calcium of the calcium caseinogenate to form calcium lactate, and caseinogen becomes precipitated. This change is due to the action of an enzyme secreted by certain micro-organisms, and would not occur if the milk were contained in closed sterilised vessels. This causes the milk to turn sour.

The milk sold in the Calcutta markets as cow's milk is largely mixed with buffalo's milk. The milk of the buffalo has a larger proportion of total solids and fat than cow's milk, and admits of a larger dilution with water. It is therefore not so digestible or pleasant to take. The intermixture of such a milk, so highly rich in fat and coagulable casein, with cow's milk renders it unfit for use as an infant-food.

Goat's milk is also used in India especially for infants. It is richer in cream, but poorer in protein than the milk of the cow. On the other hand human milk and ass's milk are richer in sugar than cow's milk.

The richness, the colour, and the flavour of cow's milk vary with the character of the food on which the animal is fed ; The common practice is to milk twice, but three times a day is not uncommon. The first part of the milk contains more water, while the last part is rich in fat. The character of the milk also varies with the class and race. In some the milk is comparatively thicker; during the rains milk is as a rule thin, and in winter much thicker.

The use of humanised cow's milk in place of, or in addition to, breast milk is not uncommon, and it is necessary that the difference between the two should be carefully noted. Breast-fed infants get their nourishment direct from the mother, at a suitable temperature and adequately mixed without any exposure to the air. The milk contains no adulterants or preservatives, and above all is bacteriologically clean and pure. Bottle-fed infants, on the other hand, get their milk which has passed through several hands, and has been exposed to endless risks of contamination in buckets, pails, cans, jugs, etc., and admitting for a moment that it was neither skimmed,

watered, nor otherwise adulterated, yet after being exposed to the dust of the streets, and to filthy surroundings of dairies, etc., it arrives in varying degrees of staleness, more or less polluted and charged with microbes.

Diseases due to Milk.—Milk is responsible for more deaths and sickness than all other foods. This is due to the fact that bacteria grow well in milk and that it is rather difficult to handle and keep it clean, fresh and in a satisfactory condition. It decomposes easily and excepting egg is the only article of food derived from the animal kingdom which is consumed in a raw state. It is most commonly adulterated and is open to all sorts of infection and pollution. The principal milk-borne diseases are -typhoid fever, diarrhœa and dysentery, cholera and tuberculosis.

In this country the dairies are generally situated near to tanks or wells, the water of which is constantly contaminated by the inflow of dung and urine, and this water is often utilised for washing the vessels and adulterating milk. The bazaar supply is always suspicious, as the vendors usually adulterate the milk with the water of tanks and wells, which is often infected.

Milk is one of the best culture media for pathogenic bacteria. The only important communicable disease common to man and cattle is tuberculosis. A large number of milch cows are more or less affected with tuberculosis in Europe, but not so in India. Attention was directed by American authorities to the fact that *T. bacilli* can be nearly always detected in the fæces of tubercular cows, even in the absence of clinically recognisable symptoms or signs of the disease. It is therefore obvious that there must be a grave danger of contamination of milk when proper care is not taken to obtain it under cleanly conditions.

Epidemics due to infected milk-supply have the following points in common :—

1. The outbreak is sudden, so also is the cessation.
2. A number of cases occur simultaneously.
3. Several members of the same family or house are attacked at one and the same time.

4. The average number of cases in each house is greater than what might have been ordinarily. An average of two attacks in a house may be considered high.

5. There will be found a common milk-supply among a large proportion of the infected houses.

6. The rich people usually suffer more, as they consume more milk than the poor.

7. Attacks are rare in families which take little or no milk.

8. Children are more frequently attacked than adults.

Adulteration of Milk. The value of milk as an article of diet in India cannot be over-estimated. Just what meat is to the Europeans such is milk for the Indians. It is of vital importance that the supply should as far as possible be pure and wholesome. Unfortunately adulteration is the rule, and a pure supply is found under exceptional circumstances. The adulterants commonly used are :—

1. Water, which is very often polluted.

2. Cane sugar or *batasa*, a preparation of treacle.

3. Cream is very often removed, and water added subsequently to maintain the specific gravity; or the evening milk after the removal of the cream is mixed with the morning milk.

4. Starch, flour, or arrowroot are often added to milk.

5. Milks of different animals are mixed together, *e.g.*, that of buffalo with cow's milk.

Preservatives in the form of borax, boric acid, formalin, etc., are not as a rule used in India.

Examination of Milk.—A sample of good milk should be opaque, of white colour, without any deposit or peculiar taste or smell. The *reaction* should be either slightly acid or alkaline, or neutral. The *specific gravity* varies from 1027 to 1034, and lessens with the increase of fat, and falls one degree for each rise of 10° F. above 60°. This is usually estimated by the lactometer which is a satisfactory guide when milk is adulterated with water only. But if sugar is added, or if water is added after skimming, then its determination cannot be taken as a

reliable index of the character of the sample. The examination should be made at a temperature of 60° F.

When milk adulterated with water is placed in a white vessel, a pale blue line can be seen where the surface of the milk touches the vessel. This can be easily detected by the naked eye so long as the amount is about one-fifth of the total volume of the milk.

Cane sugar as an adulterant is detected by adding an equal quantity of diluted hydrochloric acid and a few grains of powdered resorcin to the milk and heating it, when a blood-red colour is produced. The total solids should not be less than 11.5 per cent., but generally 12 to 13 per cent.

The presence of starch is detected by adding a solution of iodine, which colours it blue.

Fat in milk is detected by general methods, of which Leffmann-Beam's process is the best.

Preservation of Milk.—Milk can be preserved by :—

1. *Pasteurisation, i.e.*, raising it to a temperature of 167° F. for half an hour and then rapidly cooling it. By this process over 90 per cent. of the pathogenic micro-organisms are destroyed, and the natural souring of milk is delayed for 12 to 24 hours by inhibiting the fermentation bacteria.

2. Addition of peroxide of hydrogen, and heating to a temperature of 51° C. for three hours. Milk so heated is known as "Buddeised," and remains normal in taste and keeps fresh for about a week.

3. *Drying* it by passing through over-heated rollers so as to reduce it to a fine powder.

4. Addition of *antiseptics, e.g.*, formalin, boric acid, etc.

Effects of heating Milk.—When boiled in an open pan it forms a thin skin on the top ; this surface film consists of fatty matter, casein, albuminoid and ash. When heated for sometime milk becomes thicker in consistency, brownish in colour, and altered in taste. The change in colour is due to the charring of the sugar, and this thickened or condensed milk, commonly known as "Khir," is widely used in India as a delicacy. But the most important effect of boiling milk is that it is rendered

sterile. The changes brought about in the milk by heating depend upon the degree of heat and the length of exposure. Heated to about 62.8°C. for half an hour does not produce any appreciable change. Boiling however produces certain definite changes. It partially decomposes the proteins, decreases the organic phosphorus and increases the inorganic ones; precipitates phosphates, calcium and magnesium salts, and CO_2 is given off.

Digestibility of Milk.—It should be noted that milk, though a fluid, is rendered practically solid after it reaches the stomach. The clotting is due to the presence of rennin, but its value in the process of digestion has not been worked out. Indeed, Hutchison has shown that if milk could be so prepared as to prevent clotting in the stomach, its digestion in the intestines would in no way be interfered with. In fact, removal of the stomach does not hinder the digestion of milk. Boiled milk clots less readily than fresh milk, but this happens only outside the body, as the acid of the gastric juice redissolves some of the lime salts. The digestibility of milk, therefore, depends on the density of clots in the stomach. The formation of large dense clots can be avoided by taking milk in sips, when the milk is broken up in the stomach and does not form hard clots. It has been found that it takes about two hours for a glass of milk to leave the stomach, but the condition of milk has a great influence on the duration of its stay in the stomach, thus :—

602 c.c. (about a pint)	raw	leaves in	$3\frac{1}{4}$	hours
,,	,,	skimmed	,,	$3\frac{1}{4}$	,,
,,	,,	sour	,,	3	,,
,,	,,	boiled	,,	4	,,

The digestion of milk becomes complete in the intestines by the pancreatic juice, which acts more powerfully on milk than gastric juice. Absorption of milk is more or less complete; in fact, the protein and fat are absorbed as well as, or even better than, the protein and fat of beef (Hutchison). But when milk forms the only diet of an adult it is not so readily absorbed. Under normal conditions about 90 per cent. of the available potential energy reaches the blood. Milk is absorbed

with less expenditure of energy than any other food : in other words, there is less wear and tear of the intestines.

Milk contains large number of very active ferments or enzymes which are supposed to be specially valuable to infants and are destroyed by heat.

Improvement of Milk-supply.—This is one of the many vexed questions which require careful study before the supply can be improved. To effect any improvement co-operation of the milk producers (*Goalahs*) is absolutely necessary, at the same time their difficulties, the cost of food and other expenses have to be considered.

Two methods may be adopted for improving the quality of the milk-supply. *viz.*—(*a*) legislation, and (*b*) instructing the dairy men in the essentials of hygienic milk production. Dairymen are illiterate, instructions can only be given by word of mouth and practical demonstrations. Individual farms should be visited, existing conditions examined, and the special advantages of improvement explained. Practical suggestions should be given, and no one should be asked to adopt improvements which are beyond his ability and intelligence. The cleanliness of the utensils, the treatment of the milk, the local sanitation and the breeding of flies and other dangers require careful supervision.

The following rules if carefully followed will effect a marked improvement in the character of milk-supply :—

(*a*) The cow should be healthy and free from any infection or inflammatory condition of the udder. It should be properly groomed to remove dung from its body, and the udders should be properly washed.

(*b*) The tail should be secured to prevent flicking dirt attached to it during milking.

(*c*) The floors of milk sheds and approaches to the sheds should be paved and kept as clean as possible.

(*d*) All persons handling milk should be clean, should not suffer from any communicable disease, and should not be "carriers."

(*e*) The milk should be received in clean, freshly scalded metal vessels and should be protected from flies and other domestic animals.

(*f*) All bottles and cans used should be washed and sterilised.

(*g*) Do not feed the cow during milking and do not put fingers into the milk.

(*h*) Do not strain, skim or keep the milk in the cow-shed.

(*i*) Remove all refuse to a safe distance daily.

The Bacteriological Examination of Milk

Chemical examination of milk shows whether the milk is genuine or not, but it gives no idea about its hygienic quality. By chemical analysis we get no information about the possibility of the milk containing pathogenic organisms. This is of great importance, as a number of diseases are communicable through milk, indeed milk is frequently the vehicle for the transmission of many infectious diseases to man.

The bacteriological examination of milk is undertaken for the following informations :—

1. To measure the degree of fæcal pollution,

2. To find out if disease-producing organisms like *B. typhosus, B. tuberculosis* and *cholera vibrios* are present ; and

3. To ascertain if the udder of the animal is healthy or diseased.

Total Bacterial Count—This is done as in the case of water, with nutrient agar medium with definite dilutions of milk. These dilutions are made as follows : A series of glass-stoppered bottles containing 90 c.c. sterile water is taken and the first bottle receives 10 c.c. of the milk to be examined and well shaken. Ten c.c. of this is transferred to a second bottle with 90 c.c. of water and shaken. Ten c.c. of this is transferred to a third bottle and so on. Each dilution represents one-tenth dilution of the one immediately previous to it in series. In this manner dilutions should be made from 0.1 c.c. to 0.000001 c.c. and plates made from the number of dilutions beginning from the last dilution.

The following factors influence the total bacterial count, viz., the method of collection, the time that has elapsed since milking, and the temperature at which the milk has been kept.

Fæcal Bacilli Count.—This is important than the total bacterial count and should be done as described in the case of water with McConkey's broth tubes inoculated with 1 c.c. from each dilution and incubated. The presence of *B. coli* in large numbers indicates manurial and other undesirable contamination.

Estimation of B. enteritidis sporogenes.—The spores of this organism are said to be present in large numbers in cow dung. The estimation of its numbers in milk is therefore important, particularly as it does not multiply in milk. It is tested in the same way as is done for waters.

Streptococci.—These are present in milk in large numbers in cases of mastitis and ulceration of the teat. Their presence in large numbers may be taken as indicative of inflammatory diseases of the milk producing organs of the cow.

Microscopical examination of the centrifugalized and stained deposit gives an idea of the nature of the cellular elements present. A high leucocyte count accompanied by streptococci usually indicates diseased udders. The presence of pus cells may indicate purulent inflammation of the udders. Both leucocytes and pus cells are however present also in the milk of healthy cows, though in much less numbers.

Tubercle Bacilli.—A portion of the centrifugalized deposit is stained and examined microscopically for acid fast bacilli by Ziehl Nielson method, and the rest of the deposit injected into guinea pigs subcutaneously on the inner side of the leg. A negative result microscopically is not of much significance as the tubercle bacilli are present only in small numbers. When *T. bacilli* are present, an infection takes place, the glands on the inoculated side become enlarged and the bacilli can be demonstrated from films made from them.

Condensed Milk

Condensed milk is extensively imported to India, and is widely used especially by the Europeans, and in places where fresh and good milk is difficult or impossible to obtain. Condensation is effected by evaporating the water by gentle heat. This is accelerated by the reduction of atmospheric pressure in so-called vacuum pans, and is carried so far that the volume of the milk is reduced to about a quarter. Condensed milk therefore represents four times its volume of fresh milk. Dried milk is now manufactured to take the place of condensed milk. It is found in coarsely granular powder, and when diluted with water in proper proportions makes excellent milk.

Most of the condensed milks are sweetened with sugar which helps their preservation, and too often the cream is removed, and the product is really *Condensed Skim Milk.* The following are the different varieties of condensed milk found in the market.—

1. Condensed whole milk (sweetened).
2. ,, ,, ,, (unsweetened).
3. ,, skim ,, (sweetened).

The sweetened milks are for the most part good, and usually contain more cane sugar than milk solids. A good specimen may contain 11 per cent. fat, 10 per cent. protein, 14 per cent. milk sugar, and 38 per cent. cane sugar. The sweetened skimmed milks, or separated milks, or machine-skimmed milks, are very inferior to the above, and

generally contain about 1 per cent. of fat. Such a milk, therefore, is unfit for the sole nourishment of infants.

Humanised Condensed Milk.—This is condensed milk to which milk sugar and cream have been added. When diluted with water in the proper proportion it is practically identical with human milk in quantitative composition.

Digestibility of Condensed Milk. Condensed milks are more digestible than pure cow's milk, due to the fact that they do not form curds in the stomach at all, or if they do, the curds are more flocculent than of ordinary milk. It seems probable that during condensation casein undergoes certain chemical changes and hinders the formation of clots.

As a rule condensed milks are of less nutritive value than pure milk, due to their containing less fat. Hence condensed skim milk should be avoided, as well as sweetened whole milk. For infants it is better to avoid any form of condensed skim milk. If, however, fresh milk be not available, unsweetened condensed whole milk should only be used.

Preparations of Milk

Curdled Milk, Sour Milk or Dahi. This is fermented milk very largely used in this country, being more easily digested than raw or boiled milk. They are either sweetened or unsweetened, and the usual practice is to consume it within 36 hours of its preparation. The sour milk owes its virtue to the production of lactic acid, but the causative element is a *streptothrix*, with characters similar to *B. bulgaris.* Professor Kitasato has shown that 0.3 per cent. of lactic acid kills the comma bacillus in 5 hours. The addition of sugar previous to curdling does not affect the amount of lactic acid, but masks the acidity and makes it palatable. When milk turns sour the proteins of milk are partly decomposed and coagulated, and the fat particles are enclosed in the coagulated casein.

Preparation of Sour Milk.—The milk is first boiled, and when partially cooled it is inoculated with a little

curd from a previous preparation as a starter of fermentation, and kept at the room temperature for fermentation to go on. Sour milk as sold in the bazaar is hardly ever made from whole milk; the milk is deprived of its fat, and the skimmed milk is utilised for its preparation.

Butter-milk or Ghol.—This is the residual milk left after butter is taken away by churning. Ghol is generally prepared in India from sour milk or *dahi*. It is a sour-tasting fluid of varying consistency according to the amount of water present, with the casein of the milk existing in a finely coagulated state, *i.e.*, in a more easily digestible form than in ordinary curd. The lactose is in great part converted into lactic acid, and contains very little, if any, fat. It is very nutritious and is as efficacious as whey in dietetics.

Curd and Whey.—Whey is the fluid left after the curdling of the milk. It is prepared by adding essence of rennet or some weak acid to warmed milk, and setting it aside until it is firmly coagulated. The coagulum or curd (*chhana*) is then cut into pieces, strained through *muslin*, and hung up to allow the fluid (whey) to drain away. The curd contains casein and fat, while the whey contains all the original sugar, most of the mineral ingredients, and about 0.8 per cent. of protein. When milk is coagulated by rennet it gives an alkaline reaction and forms the so-called "sweet whey."

About a pint and a half of whey is obtained from a couple of pints of milk. It has a sweetish sour taste, and with equal parts of cow's milk it almost resembles human milk in composition.

The curd of milk is commonly known as "chhana" or *khilat*. Its use is practically limited to Bengal. From this curd, which contains chiefly casein and some fat or fat globules entangled in it, a large number of delicacies are prepared by the addition of sugar, syrup, etc. It contains protein 24.06, fat 2.5, and salts 1.1.

Koumiss and Kefir.—These are in reality preserved milk containing lactic and carbonic acids and a little alcohol (1 to 2 p.c.). True koumiss, as prepared by the

Tartars, is fermented mare's milk. Artificial koumiss may be brewed at home from cow's milk by the following process :—Pour fresh butter-milk (which remains after the butter has been separated by churning) 1 part, water 2 parts, cow's milk 8 parts, into a loosely covered jar or bottle and keep it in a warm place, say near a fire, for 36 to 48 hours, with frequent brisk shaking. Koumiss is an easily assimilable nutritious food and remedy.

Kefir is a fermented milk like koumiss, the ferment being a Caucasian mushroom. It can also be made at home by the addition of kefir ferment, which is a hard yellowish-brown granular body collected from the vessels from which true kefir is made, or by adding a fungus which contains yeast and *Bacillus acidi lactici.* A sparkling beverage is obtained within 24 hours. It is usually prepared from cow's milk.

In koumiss and kefir the caseinogen is thrown down in a finely flocculent and easily digested form, and is also partly peptonised. Most of the sugar is converted into lactic acid and a small amount of alcohol., and a large proportion of CO_2 are generated. 3½ quarts (daily allowance) of koumiss yield 140 grm. of protein, 80 of fat, and 140 of sugar with a combined fuel value of 1918 calories.

Cheese.—This is prepared from milk by the action of rennet, and consists of coagulated casein with varying proportions of water, fat, and salts. It may be made from whole milk, from skimmed milk, or from whole milk and cream. The ripening of cheese is the result of decomposition whereby the casein undergoes a fatty change with the formation of lime salts and fatty acids. The average composition of a good sample of cheese is : protein, 27·0 p.c. ; available protein, 25·3 p.c. ; available fat, 25·0 p.c. ; salts, 6·0 p.c. ; calorie per oz. 97·0.

Cheese is infiltrated with about 30 per cent. of fat, and is not easily digested by delicate stomachs. Digestion, however, becomes more easy if it is eaten properly masticated.

Cheese is a cheap form of animal food of high nutritive value and is a valuable substitute for meat. According to

Hutchison beef contains less than half as much nourishment as the same weight of cheese. It deteriorates rapidly in the tropics, and is chiefly adulterated with starch.

Butter.—Butter is obtained by churning either the curdled milk or the cream at a low temperature, when the fat particles clot together, entangling in their meshes water, a small amount of casein and salts. Butter is used to a much less extent by the people of this country than *ghee* or clarified butter. Butter contains casein, various fats, lactose, salts (phosphates), water, and an aromatic principle. Butter fat contains 40 per cent. of olein and is rich in those fatty acids (butyric, caproic and capric acids) which are soluble in water. An average sample of butter contains 7.5 per cent. of water, 1.0 per cent. of protein, 90.5 per cent. of fat. 1.0 per cent. of salt. The percentage of water in different samples of butter, as sold in Calcutta, rarely exceeds 16, except in Ghatal (Midnapur) butter, which gives an average of 30 per cent. Butter may be preserved by the addition of salt (not exceeding 10 per cent.), or by keeping it in water.

Butter is the most easily digested of all foods. As the butter fat approximates olein of the fat of the human body, it is of great value as food. Absorption of butter in the intestines is complete.

Though adulteration of butter is not so universal as of milk or ghee, yet it is not uncommon. Water is the chief adulterant, but admixture with low grade ghee, animal fat, and curd are also met with. In England it is chiefly adulterated with *Margarine*, which is prepared by churning melted or clarified beef or mutton fat with skimmed milk.

Ghee

Ghee is clarified butter and is used chiefly in place of butter in India. It is prepared either from the milk of the cow or of the buffalo. Buffalo ghee is whiter in appearance, while cow's ghee has a faint yellowish tinge and a pleasant sweet smell.

'Ghee is made from milk which is first boiled and then curdled. In about six hours the curdled milk is churned after adding a little water, when the butter floats on the top. This is then collected, washed, and heated, when the butter melts, and casein and water fall to the bottom. The water is then evaporated and casein that remains behind is burnt off. The floating ghee being thus free from water and organic matter can be preserved for a much longer time than butter itself. This is an important consideration in a tropical country where butter soon becomes rancid and unfit for use.

Ghee is generally used in the preparation of various kinds of food, such as sweets, *puries*, etc. It is also taken along with rice, curries, dals, etc.

Buffalo ghee contains more soluble volatile acids as determined by the Reichert-Wollny process, corresponding generally from 34 to 39 c.c. of deci-normal alkali for 5 grms. of ghee. In forty samples of purified ghee carefully prepared from pure buffalo milk in the Calcutta Municipal Laboratory for standardisation purposes, the minimum Reichert value, in terms of deci-normal soda, was found by Dr. J. Dutta and Dr. S. B. Ghose to be 30.5, and the maximum 39.3, the average being 34.5 for 5 grm. of the ghee, while the minimum Reichert value for ghee from pure cow's milk was 22, the maximum 27, and the average 24, for 5 grms. (Simpson).

The following standard for ghee has been adopted by Drs. Dutta and Ghose of Calcutta :—

	Cow	Buffalo.
Specific gravity . .	911 to 912	911 to 913
Soluble volatile acids in terms of decinormal soda by Reichert-Wollny method	24 c.c.	30.5 c.c.
Melting point . .	34° to 35.5° C	34° to 36° C
Oleo-refractometer at 45° C	–32 to 35	–32 to 35
Butyro-refractometer at 40.5° C .	41 to 42.5	41 to 42.5

Ghee as sold in the market is almost wholly prepared from buffalo milk. Ghee prepared in winter is superior to that prepared during autumn. Nearly 70 per cent. of the ghee of the Calcutta market is adulterated. The

principal adulterants are ground-nut oil (*china badam*), animal fat, mohua oil, poppy seed oil, cocoanut oil, castor oil, etc. These are not easily digested. If adulterated with animal fat it generally remains in a solid state. Plantains, boiled potatoes, and other vegetables, suet, brains of animals are said to have been found in solid ghee.

In cold weather good ghee should be clear, white, and solid, with a very faint agreeable odour. If dirty or bad smelling it should be condemned.

The presence of vegetable oils can be detected by the following test :

Take one part of the suspected ghee and four parts of chloroform in a test-tube and agitate by adding a few drops of phosphomolybdic acid ; on allowing the test-tube to stand, a green ring will be noticed at the junction of the two substances.

Animal fat may be detected by the following tests :—

1. Take equal parts (3 c.c.) of glacial acetic acid and the suspected ghee in a test-tube and dip it in warm water, agitate frequently and note the temperature at which the ghee melts. If it melts at a temperature between 29°C. and 39°C. then it may be taken as a good sample. But if the melting temperature be higher than this then it indicates adulteration with animal fat. An abnormally low figure suggests cocoanut oil. This is known as the Valenta test.

2. Shake well in a test-tube dilute carbolic acid (9 parts of the acid with one of water) $2\frac{1}{4}$ parts, with ghee one part. Allow it to stand, when the animal fat will rise to the top, while the butter fat or ghee will be dissolved by the acid.

3. *Refractive Index.* This is determined by means of a special instrument called refractometer. At 35°C. it varies for butter from 44° to 49°, and on an average 46°. Cocoanut oil gives about 43°.

CHAPTER XI

BEVERAGES AND CONDIMENTS

Beverages

Beverages are substances which by enabling food to be taken with pleasure and relish act as food accessories. They appear to stimulate digestion by acting on the digestive organs, either directly, or through the central nervous system.

Water is the universal beverage, and all other beverages contain water more or less. The utility of water in the human economy has already been discussed. It must be stated here that absorption of water does not take place in the stomach at all, and no sooner does it reach the stomach than it begins to flow out into the intestines, and the rapidity with which it passes through this organ makes it a very dangerous vehicle of infection. Therefore contaminated water is more dangerous as a carrier of disease than infected milk. Roughly, it takes about an hour for a pint of water to leave the stomach. Hot water excites the movements of the stomach and tends to open the pylorus.

Aerated and Mineral Waters.—Artificial mineral waters are prepared by dissolving in water salts of soda, lime, and magnesium, commonly present in natural water, and then charging it with CO_2 gas. Mineral waters when derived from natural springs, besides containing some natural ingredients, are impregnated with CO_2 gas.

Mineral or aerated waters have a sharp pleasant taste, and mineral water, of all other beverages, promotes the chemical process of digestion. The CO_2 gas by stimulating the movements of the stomach helps the mechanical process of digestion, and by lowering the sensibility of

the nerves of the stomach acts as a gastric sedative. When added to milk, aerated water causes it to coagulate in small flakes, and when used with acid wines, neutralises the inhibitory action of the wine on the saliva. Aerated water is not always sterile ; excepting perhaps the comma bacillus, many other organisms thrive in CO_2 gas ; moreover, aerated water is often prepared from water not always above suspicion.

Besides the above, beverages commonly used may be divided into :

A. Non-fermented drinks, and
B. Fermented drinks.

A. Non-fermented Drinks

Tea.—A hot infusion of the leaves of various plants is used as a beverage in almost all parts of the world, but the most important and widely used of all is tea. This consists of the dried leaves of a shrub called *Camellia thea* mostly cultivated in China, Japan, India (chiefly in Darjeeling and Assam), and Ceylon. The leaves from the top of the shoot, *i.e.*, the youngest ones, containing least fibre and abundant juice, are called in India *flowery* or *orange pekoe*, and form the best variety of tea. The leaves from just below and larger than the above set are called *pekoe*, and those lower than that are *souchong*.

The leaves uncurl when placed in hot water and are oval or lanceolate with serrated margin, but the serrations do not reach up to the attachment of the stalk. The primary veins run out alternately from the mid-rib nearly to the border with looped venations. The apex is notched.

The chief difference between **green** and **black** tea depends upon the time of gathering the leaves and the mode of treatment. Black tea is fermented which renders the tannic acid less soluble. Green tea is prepared from the younger leaves, which are roasted soon after gathering. It contains more tannic acid, more volatile oil, and less caffeine than black tea, so it is less stimulating and more astringent.

The *composition* of dry tea is caffeine 1 to 4 p.c., a minute trace of theophylline, and a volatile oil 0.6 p.c. which imparts the flavour and odour, and a large amount of tannic acid which precipitates albumin, gelatin and alkaloids, and is strongly astringent. But the percentage of tannin is greater in India tea, if infused longer, than in China tea. During infusion about 25 per cent. of the weight of the leaves is dissolved out. Caffeine begins to dissolve out directly the infusion has started. The tannic acid dissolves slowly and the longer the tea is infused the more will it be dissolved.

Mode of Preparation. The *proper method* of preparing tea should be by *infusion* and not by decoction, the infusion never to last for more than five minutes. If infused for a long time not only are too much soluble matters extracted, but the tea loses much of its delicate aroma. The water should just come to the boil, as prolonged boiling makes it flat ; it should neither be too soft nor hard ; hard water interferes with the extraction of some of the ingredients of the leaves. The amount of tea used in making a cup represents 1 to 2 grs. of caffeine, while coffee $1\frac{1}{4}$ to 3 grs., but some of the caffeine is always left behind. Tea leaves contain more of the caffeine than coffee, but much less tea is used per cup.

Adulteration of Tea.—Tea is often adulterated with leaves of willow, sloe, oak, etc. ; used leaves are sometimes mixed with fresh ones or coloured. Catechu and salts of iron are added to increase astringency.

Coffee.—As ordinarily used it is the seed of *Caffea arabica.* The seeds are first roasted and then ground to powder, when they are ready for use. The roasted coffee contains 0.6 to 2 p.c. of caffeine, a small amount of caffeol and a large amount of tannic acid. Caffeol is the empyreumatic oil developed in the process of roasting. It is the source of the flavour and aroma of the coffee. The tannic acid unlike that of tea does not precipitate albumin, gelatin or alkaloids and is not astringent. The aromatic oil is very volatile and deteriorates rapidly on keeping ; coffee should therefore be prepared fresh after roasting. During infusion about 25 per cent. of the coffee

is dissolved out. French coffee contains chicory, and at times burnt sugar ; in fact, coffee is largely adulterated with chicory. Dates, arrowroot, beans, maize, and acorns are also used as adulterants. Imitation coffee beans are composed of pellets of roasted wheat flour, or wheat flour and chicory or sawdust. Rye, corn and barley are also mixed with wheat for the same purpose. The substitutes for coffee are easily detected by the fact, that unlike true coffee bean, which unless over roasted, floats after roasting, they usually sink to the bottom of a glass of water.

Preparation of Coffee.—There are three methods of preparing coffee :—

1. *Filtration.*—In this process boiling water is allowed to percolate through finely ground coffee. Air should be excluded as much as possible, or else oxygen will alter the aroma. This process dissolves only 11 to 15 per cent. of the coffee.

2. *Infusion.* This is the common method. It is said to reduce the exciting influence of strong coffee without destroying its aroma.

3. *Decoction.*—This method is principally used in Turkey. The coffee seeds are ground to powder and placed in cold water which is then boiled. This is generally taken without straining.

Cocoa.—Cocoa is a powdery preparation made from chocolate by removing a portion of the fat by hydraulic pressure with or without heat. The dried residue is ground to fine powder so that it may be more readily mixed with water. The proportion of theobromin in cocoa is somewhat higher than in chocolate. It is not so widely used as tea or coffee, and not so popular a beverage with the Indians. Cocoa is derived from the seeds of the fruits of the plant *Theobroma cacao.*

The beverage " cocoa " is made by boiling the powder with water or milk for at least five minutes so that its starch may be properly hydrolysed, otherwise it is nothing but a crude mixture from which the powder tends to separate. Made with milk and sugar it has a high food value.

Chocolate is the paste made from the ripe seeds after they have been sweated, dried, roasted and deprived of their shells. The sweating or fermentation process deprives practically all the tannin and some of a bitter substance present in the ripe seeds ; roasting brings out the flavour. Chocolate contains theobromine 0.3 to 2 p.c., starch 10 p.c., vegetable protein 15 p.c., cocoa butter 30 to 50 p.c. It is sweetened with sugar and often flavoured with vanilla. It is highly nutritive and has been shown to be almost completely digestible.

Actions and Uses of Tea, Coffee, and Cocoa

Coffee and tea are not nutritive in themselves, and require no digestive process for their absorption. Addition of milk or cream and sugar however changes them into food. In tea the tannic acid precipitates the coagulable protein of the milk. But the precipitate digests in the gastric juice. Coffee and tea habits are common amongst brain workers. Many elderly people find tea particularly satisfying and soothing after reaching a period of life when the functional activity of the stomach is weakened. Coffee is less liable to produce flatulence than tea, and, therefore, should be preferred in cases of flatulent dyspepsia. Strong infusions irritate the mucous membrane, especially when taken on an empty stomach, and may either excite or keep up a condition of chronic gastric catarrh.

Taken in moderation tea gives a feeling of comfort and increases bodily and mental vigour. As a stimulant it differs from alcohol in that it is not followed by depression. In villages where the water-supply is not above suspicion it is always safe to have a cup of tea instead of water. Though the danger from infection through water is diminished by boiling, such water is not palatable, and the addition of tea makes it an agreeable drink. Strong infusions taken in large quantities often cause constipation, though with some they act as laxatives. Tea should be avoided in dyspepsia, gastric irritability, constipation, anæmia, insomnia and nervousness.

Coffee causes stimulation of the nervous system, and there is a feeling of exhilaration and diminution of the sense of fatigue. Strong coffee taken after dinner tends to retard the digestive process, it should therefore be avoided by dyspeptics. Caffeine lessens the feeling of hunger but does not prolong life in cases of starvation, and it increases tissue waste. In comparative experiments with whole companies of soldiers on the march under like conditions, Leistenstorfer, on behalf of the German government, found that when the soldiers were well supplied with food, those that were given tea or coffee could endure more prolonged and more severe marches than those that did not get tea or coffee. If no food was supplied fatigue appeared first in the tea and coffee-drinkers. Tea and coffee therefore increase the power for continuous physical work so long as the supply of nutritive material is ample, but cause early exhaustion when food is withheld (Bastedo). Excess of coffee drinking causes nervous disturbances, palpitation, insomnia, and liability to attacks of neuralgia, hysteria, and epilepsy.

From the chemical composition of cocoa it appears to be a valuable food of much nutritive value ; a cupful of beverage prepared as above with about 10 grms. of cocoa gives a nutritive value of about 150 calories. Such a drink may be taken by invalids for its food value. Chocolate, however, is of more value, and half a pint of milk and two ounces of chocolate yield about 400 calories.

Sherbets.—These are non-aerated sweetened drinks widely used in India as refreshing and cooling beverages, especially in summer. They are ordinarily prepared by dissolving sugar, sugar candy, etc., in water and flavoured with either lemon juice or some other flavouring agents.

Cocoanut Water.—This is largely used in certain parts of India, especially in Bengal, as a refreshing drink, and is useful in cases of acid dyspepsia, especially when taken after meals. It has an acid reaction with a specific gravity of 1020 to 1030, and contains 0.92 per cent. of protein, 0.62 per cent. of carbohydrates, and some salts. Where

good water for drinking purposes is not available it is always safe to use cocoanut water.

B. Fermented Drinks

Almost all fermented drinks contain a chemical substance of a powerful nature commonly known as *alcohol.* The distinctive character of alcoholic drinks depends on the particular kind of sugar or yeast used in their fermentation.

Alcoholic beverages for convenience of description may be grouped under the following heads :—

I. Beer or malt liquor.
II. Spirits.
III. Wines.
IV. Country Spirit or Arrak.
V. Toddy.

Alcohol consists of three elements, viz., C, H, and O, and is represented by the formula C_2H_6O. It is generally prepared by the fermentation of sugar by which it is split up into alcohol and carbonic acid as follows :—

$$C_6H_{12}O_6=2C_2H_6O+2CO_2.$$

Pure alcohol is lighter than water and mixes with it very readily. It is very inflammable, and when mixed with water heat is evolved. When more water is added it burns less readily, and finally it does not burn at all. The term *proof spirit* owes its origin to this property of alcohol. Alcohol when weaker than proof spirit is known as *under proof*, and when stronger as *over proof*.

1. **Beer or Malt Liquor.**—Under this head are included beer or ale, porter or stout. Beer is the product of the fermentation of malts and hops. Porter and stout are prepared almost in the same way as beer, but the malt is first roasted like coffee, and the colour is due to caramelisation of sugar.

The chief constituents of malt liquor are : alcohol, dextrine, sugar, vegetable acids, and some soluble nitrogenous matter.

II. Spirits.—The chief difference between spirits and other alcoholic beverages is that the former are products of

distillation and contain a certain percentage of alcohol. Roughly, spirits are compounds of alcohol and water, but each kind has its characteristic flavour due to the fermentation of various by-products during the process of preparation. Spirits are prepared by fermentation of various saccharine substances, and any substance capable of yielding fermentable sugar may be utilised in their manufacture.

(*a*) *Whisky.*—This is often described as a spirit obtained from fermented grain by distillation, and contains from 48 to 56 per cent. by volume of alcohol. It should be free from disagreeable odour and not less than two years old. There are two kinds of whisky :—

(*i*) *Malt Whisky* made in pot stills ; the peculiar smell is derived from the peat smoke.

(*ii*) *Grain Whisky.*—This is prepared from cereals—barley, rye, or maize—to which a little malt is added to convert the starch into sugar. These are distilled in patent stills by which some of the by-products of fermentation (fusel oil, etc.) are also separated. Excitement and a tendency to fury are caused partly by the powerful intoxicating properties imparted to the spirits by its admixture with fusel oil, etc.

(*b*) *Brandy.* This may be defined as a distilled wine, and therefore varies in quality with the character of the grapes used. When freshly distilled it is colourless and very strong. It improves with age due to the formation of volatile ether and aldehydes. Ordinarily it is not distilled from wines but prepared from "silent spirits" and coloured with burnt sugar, and flavoured. When prepared from wines it is one of the purest and least injurious form of spirits, and usually contains 45 to 55 per cent. of alcohol.

(*c*) *Rum.*—It is prepared by the fermentation of molasses, but the best variety is obtained from the direct fermentation of the juice of sugar cane. The colour is due to burnt sugar and improves in flavour by the development of ether. When kept in oak barrels it acquires an astringent property and is less irritating to the stomach. It contains from 50 to 60 per cent. of alcohol.

(*d*) *Gin.*—This is obtained by the fermentation of a mixture of rye and malt and flavoured with juniper berries, cardamoms, and other aromatics. It contains 40 to 50 per cent. of alcohol.

(*e*) *Liqueurs.*—These are spirits sweetened with cane sugar and flavoured with aromatic essences and contain about 33 to 35 per cent. of alcohol.

III. **Wines.**—Wine is the result of fermentation of grape juice, and, in case of sparkling wine, of a secondary fermentation of added sugar. The chief constituents of the juice concerned in the fermentation are: sugar—which is a mixture of grape sugar or dextrose, and fruit sugar or levulose—albuminous matter, tartaric and tannic acids. The presence of albuminous matter is important, for the yeast lives on it and splits up sugar. Natural wines can never be stronger than 16 per cent. of the volume, for the accumulated alcohol has a paralysing effect on the yeast. If the wine contains more alcohol, spirit must have been added, when it is called "fortified wine." Substances which influence the action of wines are:—

1. Ethylic alcohol and other higher alcohols.

2. Acids—Tartaric, tannic, and malic acids are the natural acids; tartaric acid is present in the form of bitartrate of potash.

3. Sugar.—A natural wine contains about ¼ per cent. of sugar, fortified wines in which the fermentation has been checked contains as much as 2 per cent.

4. Ethers are produced by the action of alcohol and acids, and two varieties, viz., volatile and fixed ethers, are present.

The principal natural wines are:—

Claret, containing 8 to 13 per cent. of alcohol by volume.

Burgundy resembles claret. It contains a higher percentage of alcohol and is richer in extractive matters.

Hocks are pale wines and have the strength of claret.

The fortified wines are:—

Sherry, contains about 15 to 22 per cent. of alcohol by weight. With age sherry develops a larger proportion of volatile ether than any other alcoholic liquor.

Port Wine contains 15 to 20 per cent. of alcohol by weight.

Champagne is prepared from black grapes. Strictly speaking it should be a natural wine with 9 to 12 per cent. of alcohol by weight.

IV. **Country Spirit or Arrak.**—These are prepared by fermentation of either rice, mohua (*Bassia latifolia*), molasses or *gur* (treacle). In case of molasses, gur or mohua, the sugar is already formed and requires dilution with water. But in rice the starch has to be converted into sugar before fermentation. It contains about 40 per cent. of pure alcohol by volume (30° under proof).

V. **Toddy.**—It is the fermented juice obtained from the spadix of the fan palm, bastard date, and cocoanut. When the fresh juice is exposed to the sun for about ten hours fermentation sets in, due to the conversion of sugar, contained in the juice, into alcohol ; the fermentation is the result of the multiplication of the yeast-fungus contained in the liquid, and the frothing is due to the production of carbon dioxide gas during fermentation. It contains about 5 per cent. of alcohol and resembles beer in its effects. The yeast is widely used in the preparation of bread. Toddy is largely consumed by the poorer classes as a cheap intoxicating drink. Spirit may be distilled from toddy.

Actions and Uses of Alcohol

Alcohol when taken into the stomach is freely absorbed, therefore it requires no digestion. It increases the secretion and stimulates the muscular activity of the stomach : There is a consensus of opinion that alcohol when immoderately taken retards digestion and leads to degeneration of the alimentary tract. Liqueurs taken after a heavy meal give a fillip to digestion and often counteract the bad effects of tea and coffee when taken at the same time.

The absorption of alcohol is very rapid, and it is found to circulate in the blood within fifteen minutes after

ingestion. If freely indulged in, it causes a permanent dilatation of the vessels of the face, especially of the nose.

Some important effects are also produced on the brain chiefly through the circulation. When the cerebral vessels are dilated, intellectual activity may for the time being be so much increased that the person is enabled to perform increased intellectual work. Thackeray, for instance, got some of his best thoughts "When driving home from drinking with his skin full of wine."

A food is a substance which helps to build tissues or furnish energy. We have already seen that proteins are responsible for building or reconstruction of tissues, while carbohydrates and fats are responsible for the production of energy. The question whether alcohol is a food has been much discussed, and from its chemical composition it is evident that it has no power to build tissues, we might therefore enquire whether it can supply energy. Alcohol possesses the power of lessening protein destruction though inferior to carbohydrate and fat. It is chemically allied to sugar and undergoes combustion in the body: it therefore furnishes some energy to the organism, and the chief claim of alcohol to the name of food is due to the fact that it will help to support life if given along with other food. It may therefore serve as a useful food in some conditions of great exhaustion or waste, where the tissues would otherwise be broken down to furnish the energy to maintain life. But while undergoing combustion in the body it tends to lessen the combustion of other substances. Consequently for ordinary persons alcohol is a very unsuitable form of food; moreover, the actual amount of energy yielded by the permissible doses of alcohol is very small and promotes heat dissipation, a loss which must have to be counteracted by the heat resulting from its own oxidation. Alcohol therefore may have a food value under special conditions, but should not be classed with foods, because its property of yielding energy is not its chief virtue, and is overshadowed by other important and untoward actions, viz:—(1) Its irritant local action; (2) Its destructive action upon the body tissues; (3) Its

narcotic action; (4) Its proneness to formation of a vicious habit (Bastedo).

Of the different forms of alcoholic drinks malt liquors, containing, as they do, large quantities of carbohydrates, are most nourishing. $1\frac{1}{2}$ oz. of bread contains as much carbohydrate as a pint of good ale. While a glass of milk yields about 184 calories, the same quantity of good beer will yield 168.

Does alcohol increase neuro-muscular activity? It has been proved that while alcohol may lead to a temporary increase of muscular activity it reduces the total output of work. The testimony of some of the experienced military experts is against the use of alcohol by soldiers in campaigns.

By its use the function of the brain is augmented, but this increase of mental and physical power is followed by a stage of diminished mental activity. It is mostly because alcohol relaxes the control over emotion that its so-called stimulant action is due, but this is very soon succeeded by the narcotic effect. Drunkenness caused by spirit is likely to be furious; that by wine, gay; and that by beer, stupid.

The question how much alcohol can be given to a person safely depends on a variety of circumstances. It is more harmful to those with sedentary habits than to those leading active and outdoor lives. Its effects also depend on the kind of beverage used. A glass of old and mature whisky is less injurious than the same quantity of raw spirit. For continuous use an ounce and a half of pure alcohol is all that can be utilised as a food in the human body daily. Roughly, $1\frac{1}{2}$ oz. of pure alcohol equals 3 oz. of whisky or brandy which is equal to $1\frac{1}{2}$ pegs, or is equivalent to 7 oz. of sherry, 15 oz. of champagne, claret, or white wine.

CONDIMENTS

The use of certain substances along with food, which though properly speaking cannot be classed as such, but which give relish to the food, is almost universal. These

are food accessories, and better known as *condiments*. Pawlow has shown that palatable and appetising food before reaching the stomach excites salivary, gastric, and pancreatic secretions. Besides giving flavour and improving the appearance of the food and thereby exciting the secretion of the digestive juices, condiments relieve flatulent distension occurring from fermentation in the intestines. Next to salt the most useful condiments are mustard, pepper, vinegar and ginger, but much difference of taste exists in the use of condiments. From long continued association certain condiments appear to serve best with certain food, thus mustard is associated with ham, black pepper with eggs, lemon and salt with rice, and when deprived of the usual relish the food tastes insipid. Substances especially useful for this purpose are those obtained from the N. O. *Labiatæ* and *Umbelliferæ*. The condiments commonly used are :—

Vinegar.—This is crude acetic acid and contains 3 to 4 per cent. of glacial acetic acid. Vinegar has well known antiseptic and preservative properties, hence it is used for pickling fish, fruits and vegetables. It also softens hard muscle fibres of meat and cellulose of green vegetables. It is largely used with salads.

Mustard.—This is the powdered seed of the black and white varieties of *Sinapis nigra* and *alba*. Pure mustard contains 14 per cent. of carbohydrate, 0.66 per cent. of volatile and 35 per cent. of fixed oil. Although it does not greatly stimulate the gastric secretion, many persons find that it increases to a certain extent the appetite and often produces a sensation of warmth or a feeling akin to hunger. The expressed oil obtained from the seeds is extensively used in cooking by the Indians in preference to the powder. The powder from the black variety is often used for the preparation of curries, etc.

It is often adulterated with starch, raising the percentage of carbohydrate over 65 per cent., or the oil may be abstracted, reducing it to as low as 7 per cent. Cayenne pepper is often added to make the taste sharper and likewise to colour.

Black pepper, cardamom, cloves, chillies, pod-pepper, coriander, anise, etc., are all used in the preparation of different articles of food to give colour, flavour, or taste. Powdered and mixed together they are sold as "curry powder."

Mustard Oil.—Mustard oil, even more than butter, ghee, or fat, is extensively used in India, especially in Bengal. It enters into the dietary of most of the people, both rich and poor. In fact, it is the only source of body fat with the poor, who can ill afford to take either milk or ghee, in their dietary. The essential oil which it contains imparts to the food a flavour not obtainable by any other oil.

Mustard oil is prepared by expression of the seeds, of which there are three varieties, the colza (*Brassica dichotoma*), the rape (*B. glauca*), and the rai (*B. junce*). The yield of the oil varies; roughly one maund of mustard seeds will produce about 15 seers of oil.

The oil is extensively adulterated. Excepting that which is manufactured in the jails, the oil is adulterated with some form of mineral oil (Batch oil or Bloomless oil). The oil seeds usually employed as adulterants are *surguja* or niger seeds, poppy seeds, *til* or sesame oil (*Sesamum indicum*), ground nut oil and mohua oil (*Bassia latifolia*), etc.

Turmeric (*Curcuma longa*).—This is also used as a condiment. Used in the form of a powder it acts as a carminative and improves the colour of cooked materials. The fishy smell is removed when fishes are cooked along with it.

Lemon.—The juice of fresh lemon is also much used, and acts as an antiscorbutic owing to the presence of *antiscorbutic vitamin.* Addition of lemon juice to some food, e.g., rice, boiled fish, etc., not only gives a flavour but renders them more digestible, and it may be regarded as having an almost specific action in promoting gastric digestion. Preserved in salt it is used as an appetiser.

Green mangoes, green olives, tamarinds, etc., are all used as chutneys or tarts.

CALCUTTA MUNICIPAL ACT

SALE OF ARTICLES OF FOOD AND DRINK GENERALLY

Sec. 493. (1).—No person shall, without a license from the Chairman, sell any four footed animal or any meat of fish intended for human food, in any place other than a Municipal or private market.

Sec. 495. (1).—No person shall sell to the prejudice of the purchaser any article of human food or drink which is not of the nature, substance, or quality of the article demanded by such purchaser ; and no person shall manufacture for sale any article of human food or drink which is not of the nature, substance or quality which it purports to be : Provided that the offence shall not be deemed to be committed under this section in the following cases, that is to say :—(*a*) Where any matter or ingredient not injurious to health has been added to any article of food or drink because the same is required for the production or preparation thereof, as an article of commerce in a state fit for carriage or consumption, and not fraudulently to increase the bulk, weight or measure of the article or conceal the inferior quality thereof ; or (*b*) where any article of food or drink is unavoidably mixed with some extraneous matter in the process of collection or preparation.

Sec. 496.—No person shall expose or hawk about for sale any animal, carcase, meat, poultry, game, fish, fruit, vegetable, corn, bread, flour, milk, ghee, butter or other article intended for human food which is diseased, unsound, unwholesome or unfit for human food.

THE BENGAL FOOD ADULTERATION ACT, 1919

(Bengal Act VI of 1919)

1. In exercise of the power conferred by sub-section (3) of section 1 of the said Act, the Governor in Council is also pleased to direct that the operation of the Act shall be limited to the following articles of food :—(*a*) milk, (*b*) butter, (*c*) ghee, (*d*) wheat-flour, (*e*) mustard oil, and (*f*) tea.

Under this Act the substances mentioned, respectively, against the articles of food named below are their normal constituents :—

Milk shall be the normal, clean and fresh secretion obtained by completely milking the udder of the healthy cow (or buffalo), properly fed and kept, and has a specific gravity of 1028 to 1030 at 15.50° C.

Butter is the substance usually known as butter made exclusively from milk or cream or both, with or without salt or other preservative and with or without the addition of colouring matter.

Ghee is the pure clarified milk fat of the buffalo or cow and has a butyro-refractometer reading of not less than 40 and not more than 42 at 40° C. and a Reichert-Wollny value in the case of cow ghee of not less than 24, in the case of buffalo ghee of not less than 30 and in the case of mixed cow and buffalo ghee of not less than 28.

Wheat-flour is the fine clean sound product made by milling wheat and bolting or dressing the resulting wheat meal and contains not less than 8 per cent. of gluten and not more than 2 per cent. of ash.

Mustard oil is the fixed oil expressed or extracted from mustard seed and has a saponification value of not less than 169 and not more than 176 and an iodine value of not less than 96 and not more than 108.

Tea is the leaves and buds of various species of Thea prepared by the usual trade processes. It contains between 4 and 8 per cent. of total ash, the proportion of this ash soluble in boiling distilled water being not less than 40 per cent. The extract obtained by boiling one part of tea with 100 parts by weight of distilled water for one hour is not less than 30 per cent. (The tea used in determining the percentage of total ash and extract is "dry tea," that is, tea dried to constant weight at 100 degrees C.)

2. In respect of the articles of food named below, of which the normal constituents have been declared under section 4 of the Act, the deficiencies in their constituents or additions of extraneous matter or proportions of water mentioned against each article of food shall, for the purposes of the Act, raise a presumption, until the contrary is proved, that the particular article of food is not genuine or is injurious to health :—

1. *Milk.*—(*a*) Where a sample of cow's milk contains less that 3.5 per cent. of milk fat, the milk is not genuine, by reason of the abstraction therefrom of milk fat or the addition thereto of water.

(*b*) Where a sample of buffalo milk contains less that 6 per cent. of milk fat, it shall be presumed, that the milk is not genuine for the same reason.

(*c*) Where a sample of cow's milk contains less than 8.5 per cent. of milk solids other than milk fat, it shall be presumed, that the milk is not genuine, by reason of the abstraction therefrom of milk solids other than fat or the addition thereto of water.

(*d*) Where a sample of buffalo milk contains less that 9 per cent. of milk solids other than milk fat, it shall be presumed, that the milk is not genuine.

2. *Butter.*—Where the proportion of water in a sample of butter (not being sold and labelled as Ghatal butter) exceeds 16 per cent., it shall be presumed, that the butter is not genuine, by reason of the excessive amount of water therein.

3. *Wheat-flour.*—(*a*) Where the proportion of ash in a sample of wheat-flour exceeds 2 per cent., it shall be presumed, that the wheat-flour is not genuine by reason of the excessive amount of extraneous mineral matter therein.

(*b*) Where the proportion of gluten in a sample of wheat-flour contains less than 8 per cent. of gluten, it shall be presumed, that the wheat-flour is not genuine, by reason of the deficiency of gluten therein.

4. *Ghee.*—(*a*) Where in any sample of ghee the butyro-refractometor reading at 10° C. is less than 40 or more than 42, it shall be presumed, that the ghee is not genuine, by reason of the addition thereto of extraneous fat or oil.

(*b*) Where in a sample of cow ghee, the Reichert-Wollny value is less than 24, it shall be presumed, that the ghee is not genuine, by reason of the addition thereto of extraneous fat or oil.

(*c*) Where in a sample of buffalo ghee, the Reichert-Wollny value is less than 30, it shall be presumed, that the ghee is not genuine, for the same reason.

(*d*) Where in a sample of mixed cow and buffalo ghee, the Reichert-Wollny value is less than 28, it shall be presumed, that the ghee is not genuine

5. *Mustard oil.*—(*a*) Where in a sample of mustard oil, the saponification value is less than 169 or more than 176, it shall be presumed, that the mustard oil is not genuine by reason of the addition thereto of extraneous oil.

(*b*) Where in a sample of mustard oil, the iodine value is less than 96 or more than 108, it shall be presumed, that the mustard oil is not genuine by reason of the addition thereto of extraneous oil.

6. *Tea.*—Where the proportion of total ash (determined on dry tea, that is, tea dried to constant weight at 100°C.) is below 4 per cent., it shall be presumed that the tea is not genuine by reason of the abstraction therefrom of soluble matter ; when the proportion of total ash (determined on dry tea, that is, tea dried to constant weight at 100°C.) is over 8 per cent., it shall be presumed that the tea is not genuine by reason of the addition thereto of extraneous matter ; when in the total ash, as determined above the proportion of ash soluble in boiling water is less than 40 per cent., it shall be presumed that the tea is not genuine by reason of the abstraction therefrom of soluble matter ; when the extract obtained by boiling dry tea (that is, tea dried to constant weight at 100°C.) with 100 parts by weight of distilled water for one hour is less than 30 per cent., it shall be presumed that the tea is not genuine by reason of the abstraction therefrom of soluble matter, where leaves are present not conforming in structure to those of the Camellia genus, it shall be presumed, unless the contrary is proved, that the tea is not genuine by reason of the addition thereto of extraneous matter. Tea shall be derived exclusively from the leaves and buds of plants of the "Tea" species.

CHAPTER XII

COLLECTION, REMOVAL, AND DISPOSAL OF REFUSE

In every town, public health largely depends on the efficiency with which all refuse—excreta (fæces and urine), and other house refuse (ashes, dust, slop-water, etc.)—is collected and removed. This may be effected by the following methods :—

I. **Scavenging.**—This includes the collection and removal of ashes, dust, sweepings, and other domestic and trade refuse by manual or mechanical labour.

II. **Conservancy or the Dry System.**—In this system slop water is got rid of by drains, and solid and liquid excreta are collected from privies by either hand or by mechanical means.

III. **Water-Carriage or the Wet-System.**—This consists of removal of human excreta along with the liquid refuse of houses by a system of drains and sewers to some place outside the town limits.

I. SCAVENGING

Town and house refuse consists principally of organic substances derived from articles of food, dust, and a certain amount of mineral matter; but it varies with the season of the year and habits of the people. In places like Calcutta refuse consists principally of street sweepings, kitchen refuse, vegetables, waste paper, ash, broken glass, bits of metals, rags, fæces of animals, specially of cows, horse, buffalo and dog, etc. Organic refuse has a tendency to undergo putrefactive changes, when it gives off an offensive smell and serves as a breeding-place for flies, and provides food for rats, vermin, etc.; hence the neces-

sity for its early removal. The refuse is received either in ashpits or dustbins, as their deposit on the roadside is objectionable because they are liable to be carried about by the wind, or washed out of the heap during rains. Dustbins are best made with corrugated iron. They should not be too large; the simplest shape being a circular one open at both ends, provided with a pair of handles. They should be placed on a raised, concreted and cemented surface, always at a fair distance from any dwelling-house, and provided with a cover. In India owing to the climatic conditions and rains the refuse decomposes very rapidly, and flies, mosquitoes and ver-

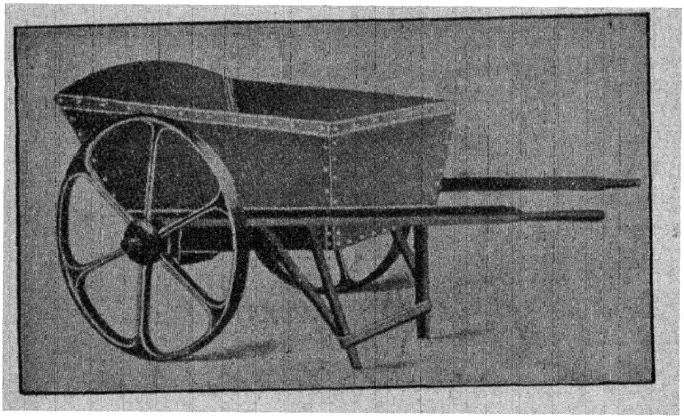


FIG. 10.—WHEELBARROW.

mins multiply enormously. It is therefore necessary that the contents of the dustbins should be removed daily, or twice a day, by especially constructed carts. These carts are generally drawn by bullocks, horses or buffaloes. Motor vans which can be tilted by a mechanical arrangement are now in use in places like Calcutta and Bombay for the collection of street refuse from the dust bins. All these refuse carts should be covered to prevent nuisance when passing along roads fully loaded.

Wheelbarrows are small hand driven carts used to collect refuse from narrow lanes and bye lanes where refuse carts drawn by bullocks and horses cannot go. The refuse is then deposited in the dust bins.

Disposal of Refuse.—After collection there are two methods of disposal of refuse, viz., *dumping* and *incineration.*

1. *Dumping.*—In this method the refuse is generally utilised in filling up insanitary tanks, low-lying lands (reclamation), hollows, etc. This ground should be outside the limits of the town and away from human habitation, as it creates a serious nuisance and often gives off most noxious gases ; and foul liquid draining from the heap may pollute the nearest water-supply. Moreover, it breeds flies and harbours rats. Materials from dismantled houses can best be employed for the covering of refuse heaps or filling up tanks, *dobas,* etc. (*See* Made-Soil page 107).

In most of the towns in india the practice is to throw house refuse on the streets at all hours of the day. In Calcutta the refuse is taken to the unloading platforms whence it is carried by railway trucks and utilised in reclaiming low-lying lands.

2. *Incineration.*—One of the best methods of disposal of refuse is to render the same harmless by burning. This is generally done in a "Destructor Furnace" or "Incinerator". By this process the refuse is reduced to about one-fourth of its original weight, and the organic matter is transformed into innocuous vapours—carbon dioxide and nitrogen. The residuum left after the combustion is a mass of hard material called "clinkers," which are usually utilised for road-making ; powdered and mixed with lime, they form cement.

Big towns should be divided into districts, and each one provided with a destructor furnace which may be placed in a central position to minimise the expense of transport.

During the last war quite a large number of incinerators were used, but as far as the general principles are concerned most of them are practically the same, and

are modified to meet the local conditions. All incinerators have the following features in common :—

1. A furnace or combustion chamber lined with brick.

2. A suitable arrangement with a platform for tipping the refuse through a series of feeding holes through which the refuse falls into the cells below.

3. After the refuse has been brought together by the stokers it is burnt down to $\frac{1}{3}$ to $\frac{1}{4}$ of its original weight.

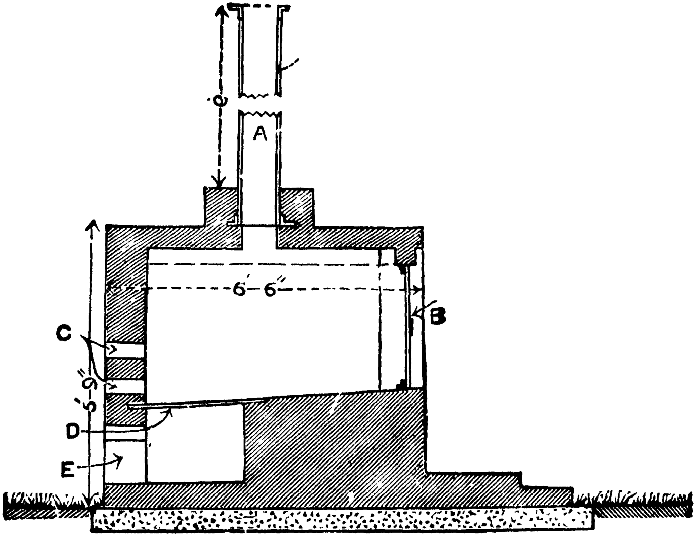


Fig. 11.—INCINERATOR. Longitudinal section.

A. Chimney. B, Charging door. C. Openings for stoking. D. Iron grating. E. Opening for removing ashes.

4. A baffle plate so placed that all fumes are driven through the hottest part of the incinerator, or combustion chamber before passing up the chimney.

Both the Meldrum and Horsefall destructors were used during the war with considerable success. The Meldrum destructor depends for its action upon a forced draught produced by a steam jet. When properly used it acts very satisfactorily, but needs great care for succes-

ful and continuous work (*See* Fig. 15). The fumes are cremated by passing through a combustion chamber, which separates the furnace from the flue. For a large type it is necessary to feed from a platform at the top, the material passing directly on to the fire.

The incinerators built of mud or iron without fire brick do not give satisfactory results. They are however suitable for fairs and melahs of short duration. The "Beehive Incinerator" which was extensively used during the war will be found to give very satisfactory results under such conditions (*see* Village Sanitation). A common defect in many incinerators is that the draught is not sufficient, with the result that they give off offensive smoke which creates a nuisance.

II. CONSERVANCY SYSTEM

The primary object of this system is to get rid of excreta as soon as possible without allowing decomposition to set in. Fæcal matter should not be allowed either to be deposited within a few feet of the atmosphere we breathe or decompose for any length of time. The accumulation of filth means pollution of soil, air-and water-supply, and breeding of flies and consequent disease. In small municipal towns for want of sufficient funds it is not possible to lay down sewers for the removal of excreta, neither can they be allowed to accumulate about the house. Hence removal of excreta by the dry method is in vogue in the mofussil.

An adult European male living on a mixed diet passes about four ounces of solid and fifty ounces of liquid excreta daily, while an Indian, who is more a vegetarian, passes between eight to sixteen ounces of solid. If all ages and both sexes are considered, the average daily amount of solid excreta per head may be taken at twelve ounces. In India water, instead of paper, is used for cleansing purposes, and this ablution water together with the liquid excreta make up about eighty ounces. The average daily amount of excreta to be dealt with in a mixed population can be estimated by multiplying twelve

ounces of solid and eighty of liquid by the number of persons. The important constituents of excreta are nitrogen, phosphates, and potash. Fæcal matter especially when mixed with urine, undergoes rapid decomposition and gives rise to foul gases, chiefly organic vapours and ammonium sulphide. This generally happens in the case of neglected privies, cesspools, etc. It is a matter of practical importance that the excreta should be protected from rain and flood water, or else not only will the sewage be not efficiently removed, but the whole mass will undergo fermentation and create a serious nuisance.

Latrines.—People living in villages usually visit the gardens or adjacent land for purposes of nature, and fæces charged with pathogenic organisms and their spores or eggs are liable to be conveyed by dirty hands and feet, or flies to the human system. Furthermore, after rains, the washings often pollute tanks or any source of water-supply near about, and help in the propagation of disease. It is therefore necessary that some arrangement in the shape of latrines or privies should be made to overcome these defects.

For practical purposes an arbitrary distinction is drawn between a *latrine* and a *privy*. A privy for public use is a latrine. The following points should be observed in the construction of privies :—

1. The design should be such that all excreta and washings automatically find their way into some receptacle, so that no brushing will be necessary.

2. The materials used should be non-absorbent to prevent pollution of the soil through soakage.

3. Satisfactory arrangements for the reception of night-soil, and separation of liquid excreta, and for the cleansing of the same, should be made (*see* Fig. 13.).

4. The trap-door (for the sweeper) should be easily accessible, and the passage leading to it should be decent.

5. Ventilation should be thorough and efficient, even when the doors are closed.

A **service privy** resembles the pail system inasmuch as the fæcal matter is received into a movable receptacle of some form.

An **ideal latrine or privy** may be described under the following heads :—

1. The superstructure which includes the roof and the walls.
2. The floor and the seat.
3. The collecting chamber.

1. *The Roof.*- The roof may be either terraced or sloping. Sloping roofs may be of corrugated iron, tiles, or grass. Of these corrugated iron is the best to use.

The *walls* may be either of brick work, corrugated iron, or bamboo matting. They should be pigeon-holed towards the upper half for proper ventilation. It is better that the roof should have an ample ridge ventilation ; or an opening of about 2 ft. may be left between the wall and the roof as shown in the figure. Large ventilating holes, each 2 ft. square, may also serve the same purpose.

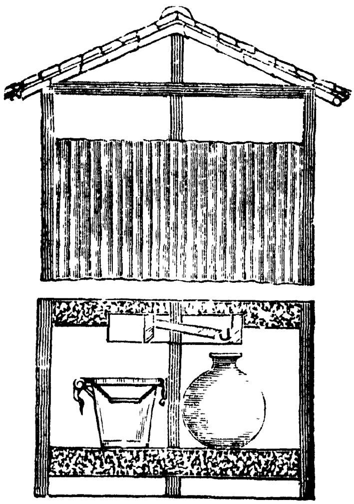


FIG. 12.—PRIVATE LATRINE.
Showing the super-structure, the walls, the collecting chamber with antisplash pail, and a vessel for collection of urine and water.

2. *The Floor and the Seat.* The *floor* should be made of some impervious material, *e.g.*, brickwork set in cement, slate, stone, or iron, and should be sloped towards an opening or drain leading to a receptacle. The best material is either vitrified brick, marble, or granolithic cement. These are non-absorbent, and when properly laid make an elegant floor which can be easily cleaned, and require no further attention.

The *Foot Rests* must be in the right position and not too wide apart, or else the fæces will not fall into the

receptacle below. The sides of the opening should be sloped from above downwards and outwards, this will do away with the disadvantage of fouling the sides.

3. *The Collecting Chamber* should always be of masonry work with the walls and floors cemented and corners rounded off to facilitate easy and thorough cleansing. The floor should be concreted and raised 6 in. above the level of the surrounding ground with a slope leading to an opening. The trap-door should be well-fitting and properly tarred.

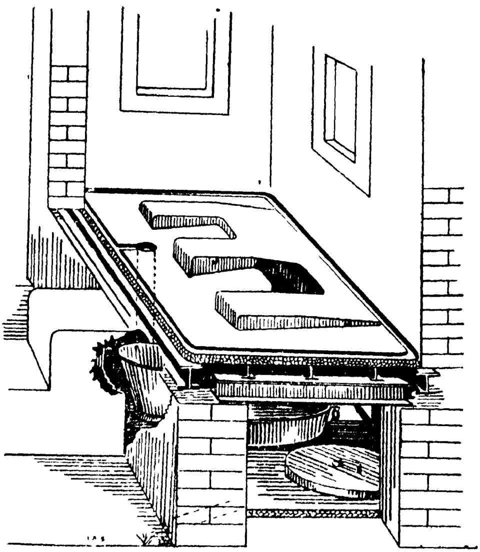


FIG. 13.—AN IMPROVED TYPE OF PRIVATE LATRINE.
Showing the seat arrangement and separation system.

The *Pail* or receptacle should be placed about 6 in. under the seat to prevent splashing. In some cases this distance is very great and may be 8 ft. to 10 ft. or even more. The best receptacle is a tarred iron or wooden

bucket, or an earthenware vessel (*gumla*). This should be periodically taken out, washed, and tarred. To prevent splashing special antisplash pails of galvanised iron with a removable conical cover, as shown in the figure 12, should be used. These can be fitted with a cover and carried directly to the trenching ground, and will do away with the use of soil carts.

The practice of using water for cleansing purposes in India necessitates a separate arrangement. The urine and ablution water are carried by a separate conduit or pipe and collected into a special receptacle placed at a convenient site in the collecting chamber, while the solid excreta fall directly on the bucket. The receptacle for the urine and ablution water may be a tarred earthenware or iron vessel. This separation system has many advantages. The liquid being collected in a separate receptacle decomposition does not take place so rapidly and therefore the latrine becomes less offensive. There is less nuisance during removal. Apart from these advantages the separation system prevents overflowing of the pails, which so often happens when used by a large family, and the possibility of splashing. To avoid splashing people often use any part of the latrine other than over the proper opening and thus make it horribly filthy. Therefore especially designed platforms and foot rests must be constructed to separate the urine and ablution water. The figure 13 is a design of such a platform and may be made of glazed stoneware, brick-work plastered with cement, or of cast iron. This privy is designed for better class people.

Service privies should be at least 6 ft. away from any dwelling, to permit a free circulation of air between the house and the privies. From a well or a tank they should be at a distance of at least 50 ft. The pail contents should as far as possible be kept dry by throwing ash, sand, or dry powdered earth into the pail after each visit. This has the advantage of lessening the emanations of foul vapours. The contents of the pail as well as of the cesspit should be removed at least once a day.

Besides the above the following methods are also used :—

1. The well system.
2. The open-air privy in field.
3. The trench latrines.
4. The commode system.
5. The receptacle latrine.

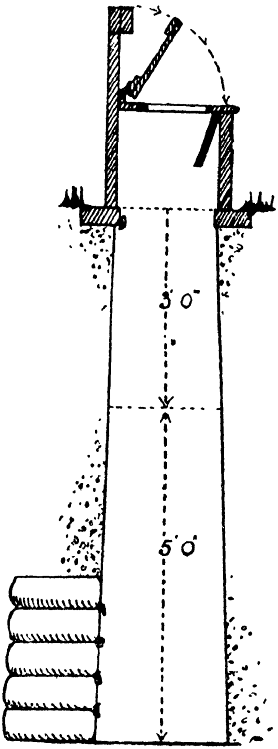


FIG. 14.—PIT LATRINE (From History of the Great War).

1. **The Well System.**—In this system there is no movable receptacle, but the excreta are received in a hole or well, usually 6 ft. to 20 ft. deep, sunk in the ground. This system is most objectionable from a sanitary point of view, as not only foul gases are evolved, but there is risk of pollution of water-supply through soakage, especially after a rise in the level of the sub-soil water.

A modification of well privy is now largely used in the form of "Pit Latrines." By this system, provided the site and soil are favourable, the effect is more or less automatic. The excreta are finally and quickly disposed of, thereby rendering any further handling unnecessary, which makes the ordinary pail latrine so objectionable. These were largely used in France during the war.

(*a*) *The Site.*—It should be on an elevated land and well away from and below the water supply, so that the flow of ground water is away from this supply. The soil should be porous one and the pit should be unlined. A clay soil or a soil subject to frequent floodings, is unsuitable. The upper layer of the sub-soil water should

not be tapped. When there is excess of water bacterial action is suspended, and putrefaction takes place with the production of offensive gases. It is therefore necessary to keep the pit as dry as possible. Disinfectants by killing the bacteria stop the nitrifying process.

(*b*) *Depth.*—This will depend upon the location of the site and the nature of the soil. Ordinarily 6 to 8 ft. is enough. The number of bacteria diminishes below this depth.

(*c*) *Seat.*—It is better whenever possible to have the seat made of wood or sand stones. The wood should be ant-proof, and tarred or creosoted all over, and should rest on a layer of bricks to make it higher than the adjoining ground.

(*d*) *Drainage.*—It is essential that a well constructed drain to surround the whole building, to carry the rain and storm water, should be provided for.

2. **The Open-air Privy in the Field.**—In villages and rural areas where no proper arrangement for disposal of night-soil exists, people usually go to some open field or waste land to empty their bowels and then use a tank or any source of water available for ablution purposes. Such a practice should be discouraged as it is very insanitary and also the chief factor in spreading hookworm infection.

3. **The Trench Latrines.**—These are made by digging long trenches usually 1 to 2 feet deep and 8-10 in. wide. The person using it should place one foot on each side of the trench and squat in such a manner that the urine, ablution water and the solid excreta should pass directly into the trench. They should be properly screened and after use should be filled up with the excavated earth. These latrines are satisfactory as a temporary arrangement during fairs (which see), etc., or in rural areas where there is no organised conservancy system.

4. **The Commode System.**—The use of the commode is very popular with the Europeans in India. The arrangement is very simple and consists of a porcelain or enamelled pan fitted in a wooden or iron stand, the top of which

forms the seat. If proper care is taken to keep the pan clean there can be no objection to its use.

5. **The Receptacle Latrine.**—This form of latrine was extensively used during the war with much success. It consists of a wooden seat fixed directly on the latrine bucket. The seat is fitted with a self-closing lid which

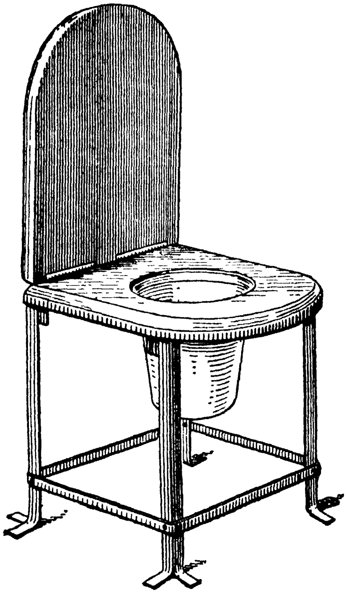


FIG. 15.—THE COMMODE.

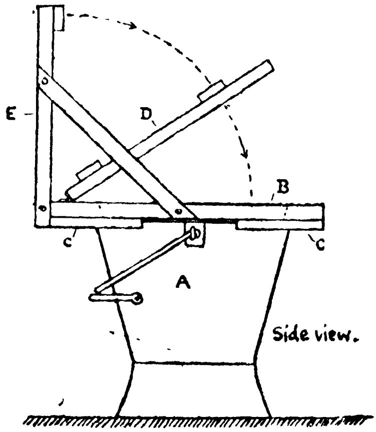


FIG. 16 —FLY-PROOF RECEPTACLE LATRINE.
(From History of the Great War).

makes it fly-proof. The individual pails can be removed directly either into the trenching ground or for incineration; or the contents may be transferred into one large receptacle for removal. This receptacle latrine may conveniently be placed in the bath room, and provided proper care is taken to keep it clean and periodically disinfected it will be found very satisfactory in the moffusil stations.

Public Latrines

There are two types of public latrines :—

1. Fixed or permanent.
2. Movable or temporary.

1. **Fixed or Permanent Latrines.**—These should be constructed on good *pucca* plinths with a slope on one side, and no wood or any other absorbent material should enter into their construction. There should be a series of seats with separate receptacles for solid and liquid excreta, or the urine and wash-water may be received in a pucca cesspit. The approaches to the latrines should be properly made, and a sweeper retained for each latrine, which should be cleansed at least twice a day. Every latrine should be provided with a light at night.

A large number of smaller latrines suitably distributed is much more effective than a few large ones which are much more costly to construct and maintain. Such a latrine is very useful for general use, and may with advantage be placed in railway stations and other public places. The great point to be attended to in all public latrines is efficient ventilation and proper cleansing. The best material for their construction is corrugated iron.

2. **Movable Latrines.**—These are of great use in segregation camps, *melas* (fairs), and all other places where latrines are required only temporarily. They are also convenient in cantonments or other situations where fixed latrines are not suitable. The latrine should be easy of transport, and when not in use, so compact that it can be packed away in a godown or shed. The receptacle for night-soil is simply placed on the ground with bricks for foot rests. The roof, sides, and partitions are best made with corrugated iron sheeting. They are removed when the ground becomes foul and bad smelling, which should be dug up and left exposed to the sun and air for about a year. No masonry work should enter into their construction, and the site should always be high. The latrines should be removed once in a month during the rains and every second month during the dry season.

COLLECTION OF NIGHT-SOIL

In India the collection of night-soil is usually done by a regularly organised gang of sweepers (*methers*), who daily remove the contents of the privy pans into tarred wooden buckets (pails) which are carried either direct to the trenching-ground, or their contents transferred into night-soil carts at the depots, and then taken to the trenching-ground, for final disposal. In the outskirts of Calcutta, where a hand removal system still exists, the night-soil is carried to depots and there emptied into the main sewer. The collection of night-soil should be done in the early hours of the morning, and if possible once again in the afternoon. Cesspit contents and urine should also be removed by night-soil carts for disposal.

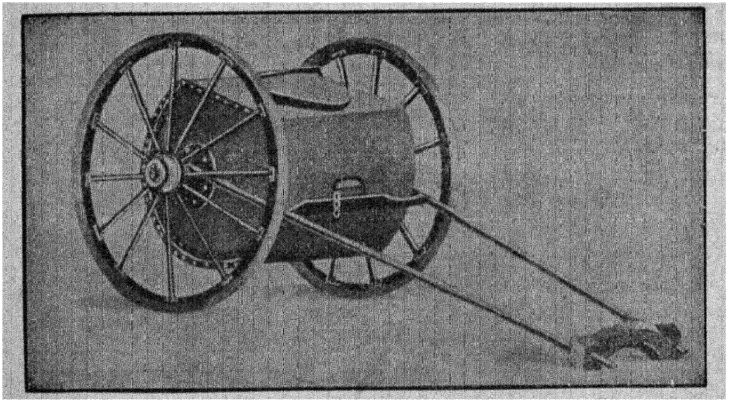


FIG. 17.—NIGHT-SOIL CART.

Considering the fact that nuisance increases with the bulk of the population, and with the number of handlings; it is always better, whenever possible, to remove night-soil by substituting special metal receptacles in place of *gumlas*, which can be carried bodily to the trenching-ground either by a sling, or on a especially constructed "Receptacle Cart." This will have the effect of minimising

nuisance by doing away with the ordinary night-soil carts, removing the filth direct from the latrines in absolutely air-tight sealed receptacles without being moved or stirred, and avoiding spillage or the spread of offensive odour.

Night-soil Carts. -These are usually made of steel with iron wheels. They have a capacity to hold 90 to 110 gallons, and are fitted with a double lid which can be sealed with a little earth. The body is pear-shaped and empties itself by revolving on the axles.

Night-soil depots should be located away from habita tions and screened from public view.

Disposal of Night-soil

The disposal of night-soil in such a manner as to secure it from being any longer a nuisance or menace to public health is a difficult problem. But all excremental matters can safely be disposed of either (1) by *trenching*; or (2) by complete burning (*incineration*). Trenching may be done "in situ" as in the case of shallow trench latrines or deep pit latrines; or night-soil may be removed to a distance and buried for agricultural purposes in trenches or deep pits. Burning is done in some special form of incinerators. All these methods were used during the last war, but the best results were obtained where "Fly-proof Receptacle Latrines" (Fig. 16) were used and the contents incinerated.

I. **A trenching-ground** is a plot of land where the night-soil is deposited under the soil in shallow trenches. Strictly speaking trenching of night-soil is a biological process, but it is not customary to reckon it as such. The following is an extract from a circular of the Sanitary Commissioner of Bengal regarding the proper management of trenching-grounds :—

"The objects of trenching are to dispose of night-soil with the least possible offence as regards smell and to prevent the breeding of flies which are great carriers of disease. It has been found by experience that deep trenching is most objectionable from a sanitary point of

view, as in this case the disintegration of night-soil is too long delayed and the ground does not become properly purified by cultivation....Shallow method of trenching, which is by far the best, should therefore be carried out properly.....The trenches for this purpose should be dug 1 ft. apart, should be either 1 or 2 ft. in breadth and 1 ft. deep; night-soil to the depth of 3 in. only should be allowed to be put into them and should then be covered in with the excavated earth....For every 25 gallons of sewage a trench 2 ft. broad and 1 ft. deep filled to the extent of 3 in. should be 8 ft. long, as $2 \times \frac{1}{4} \times 8 = 4$ cub. ft. or 25 gallons of sewage. The trenching-ground should be divided into three plots, so that every plot may be trenched once every three years. The remaining two plots must be kept under cultivation while the other is being used. Cultivation is a vital element in the success of a trenching-ground, as without this method of purification the ground becomes sewage-sick and unfit for re-trenching."

The following points should be observed in the management of a trenching-ground:—

1. The site should be high and well open to the south and west. The soil should be dry and of a light porous nature; clay soil, being retentive, is unsatisfactory, while light sandy loam is good.

2. It should always be in the outskirts of a town, and at a distance of about 600 yds. from a dwelling-place.

3. A row of trees should be planted to separate the ground; this will also prevent infective dust from being blown into the town.

4. It should always be at a distance from the sources of water-supply.

5. It should be provided either with a well or tank for washing the buckets and carts, and irrigating the ground under cultivation.

6. There should be good roads within the ground.

7. Arrangements should be made for draining off rain water to low-lying cultivated lands.

8. Trenching should be systematic and should begin from one end of the ground.

9. Too shallow trenches formerly advocated do not give satisfactory results ; one 18 in. deep, 2 ft. wide and 15 to 30 ft. long serves the purpose very well.

10. Too much night-soil should not be put in the trenches as then it will percolate up through the earth and reaching the surface will create great nuisance.

11. The carts should not be taken directly into the trenches but emptied into pails in the depot of the trenching ground, and these pails are then emptied into the trenches.

12. The earth must be broken up and the trenches covered as soon as possible. In filling up the trench excess of earth should be used to form a dome and not in level with the surface. This will allow certain amount of sinkage due to settling of the earth without forming a hollow or depression where water can collect and thus create a nuisance.

13. There should be a covered shed for the storage of utensils, etc.

14. The carts and pails should be thoroughly cleansed both inside and outside by some liquid disinfectant, *e.g.* izal, cyllin, etc.

15. Cultivation should be carried out three months after trenching. The ground should be deep-hoed, ploughed up and sown at first with dhoop grass, sugar cane or tobacco. After this all kinds of vegetables may be grown.

II. **Incineration of Night-soil.**—This method of disposal by completely burning up night-soil is being greatly advocated in India. If properly carried out in a well-designed furnace destructor it will be found to be very sanitary ; the possibility of contaminating the water-supply or the danger of polluting the air by smoke or vapour will be reduced to a minimum.

The incineration of night soil may or may not be combined with the incineration of street refuse. In some places certain amount of refuse may be utilised as fuel, but this is not always so. Where the street refuse contains dry grass, straw, rags, paper and other inoffensive combustible material these may furnish all the fuel neces-

sary. It is not always that one gets in Indian towns enough combustible material to utilise the refuse for incineration

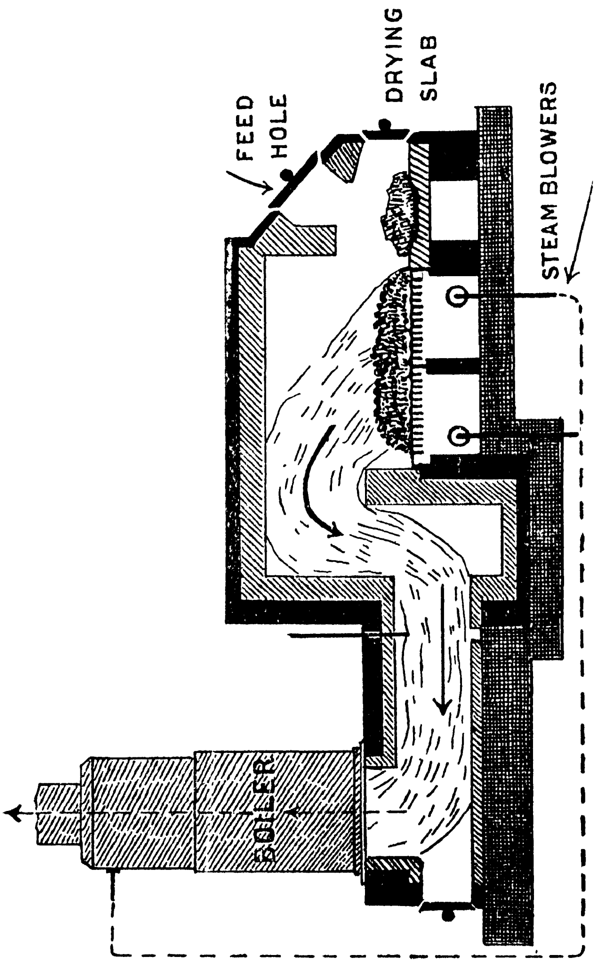


Fig. 18.—Meldrum Incinerator. (From History of the Great War).

of night-soil without any addition of extra fuel. This naturally makes incineration an expensive process.

The incinerators for night-soil should be of a closed type, their main principles have already been discussed (*see* p. 221), but incineration to be successful the following conditions are necessary :—

1. The incinerator must be so built as will stand rough usage and the materials used should stand extreme heat.

2. Since a good draught is essential, the air inlets must be adequate, and the chimney sufficiently large. The openings of the grating should not be more than $1\frac{1}{4}$ to 2 in.

3. The smoke should be rendered inodorous either by providing a baffle plate or by placing a horizontal grid a little below the entry into the flue. This will allow the gas to pass through a layer of glowing fuel from a fire lighted on this grate.

4. The mixing of the night-soil with the combustible material should be done in proper proportion. The fuel should be dry and the mixture should be put in the fire when it is blazing one. The stokers should be well trained.

5. As mentioned before the ordinary street refuse is not always inflammable and may not serve as a fuel, and a good supply of combustible material is therefore necessary. Usually saw dust, coal dust, wood shaving, dry grass, or straw are used for the purpose. It must be noted that the possibility of smoke nuisance is less if plenty of fuel is mixed with the night-soil.

6. As it is essential that the fuel should be dry, a covered shed for the storage of fuel must be provided for. During the rains it is impossible to keep any combustible material in a readily inflammable condition. The mixing platform should have concrete floor.

Disadvantages of the Hand Removal System :—

1. From a financial point of view it is not economical, as it necessitates the employment of a large number of sweepers, carts, bullocks, etc.

2. Its success depends absolutely on the way in which the work is carried out. The sweepers are very difficult

to manage, and a badly worked system is a source of great danger and nuisance.

3. The wear and tear of night-soil carts, pails, etc., are very great.

4. There are dangers of contamination of air and water, and spread of infection through flies.

5. It is difficult to manage in towns having a large population.

6. If suitable soil is not available, or if the trenching ground is not properly managed, the place breeds flies and becomes a menace to public health.

7. The transfer of night-soil from pails to buckets, and from buckets to carts, creates great nuisance.

III. WATER-CARRIAGE SYSTEM

Disposal of Slop Water. —The conservancy system does not provide for the removal of domestic or other waste-water, and to carry this out efficiently in towns and villages is a very difficult problem, for these are no less impure than the ordinary sewage of water-closet towns. A system of drains, therefore, for the removal of such water is necessary. The slop water from isolated village houses is usually conveyed by pervious (*kutcha*) drains, which are merely shallow open trenches or elongated cesspools, to the nearest tank, ditch, garden, or open land. These drains are very inefficient and their general plan and construction are faulty in the extreme. Their sides have no proper slope to prevent the falling in of loose earth, their bed no sufficient inclination to permit the water to pass with sufficient velocity to carry solid filth and prevent their deposition. The consequences that may follow such a practice are obvious . they form a suitable breeding-place for mosquitoes, flies, etc., pollute the neighbouring water-supply after saturating the soil by soakage, and during the rains form dirty, fermenting, and offensive puddles. Another common defect of drains in Indian towns or villages is the want of any suitable outfall. In most cases they lead into tanks and *dobas,* while in others they lead into the

open country and terminate in the rice fields and marshy lands, which remain sloppy during the rainy season and for some time after. During all this time the village drains remain full of water and thus keep up that saturation and humidity of the sub-soil and foundations so detrimental to the health of the people.

Weeds and other small plants growing in these drains materially impede the free flow of their contents. Arrangements should therefore be made to remove these vegetations periodically and to maintain the level of these drains. But by far the best method is to have the drains either made *pucca*, or constructed with some non-absorbent material, such as channelled Ranigunge or half-round patent-stone pipes, to prevent soakage. Wherever possible all drains should be **V**-shaped on section so that a small amount of water will suffice to flush them, and very little water will accumulate in the narrow bottom of the drains. Large drains should also be similar in section, but the bottoms may be rounded. Sewage can be best disposed of by irrigation over agricultural lands or open fields, while the slop water of individual houses may be collected in suitable vessels or pits, and then removed to some cultivated land for final disposal.

Sewage and Removal of Sewage

Waste-water consisting of liquid and solid human excreta, together with liquid refuse from cowsheds, stables, houses, factories, etc., is known by the term **sewage.** Waste-water from houses, etc., unmixed with solid excreta is usually known as **sullage.**

Removal of Sewage.—There are two principal methods of removal of sewage, viz. :—

I. **Conservancy system** or dry method.—This has already been discussed.

II. **Water-Carriage System.**—In this system the solid together with the liquid refuse is carried from the immediate neighbourhood of habitations by a flush of water. Owing to the initial expense incurred in its outlay and

also for the abundance of water-supply that it demands, the water-carriage system cannot be introduced everywhere. It appears to be cheaper in the long run, and is perhaps the cleanest, quickest, and most sanitary method of removing night-soil. For these considerations the water-carriage system is indispensable in big towns.

House Drainage

A complete system of house drainage consists of :

A. Water-closet.
B. Soil pipe.
C. House drain.
D. Traps.

A. Water-closet.—A water closet is a sanitary installation for the reception of human excrement, and having connection with a sewer by a pipe, removes the excrement, when deposited, through the agency of water. It should be in a detached portion of the house, and at least two of its sides open to the outside air. The closet apartment is too often a crammed, dark, ill-ventilated room. In fact no apartment of a house demands more free ventilation than this, yet perhaps there is none which receives less. There should be ample provision for cross ventilation. When a closet is required for each storey the apartments should form a separate tower connected to the main building by overhead bridges.

The essential features of a good water-closet are that it should be simple in construction and not liable to get out of order, it should be inodorous, the basin should be of some non-absorbent and indestructible material, the excrement shall fall without any external agency into the proper portion or the closet, and the flushing should be of sufficient force to wash the basin clean and remove all traces of excreta with a minimum quantity of water.

A water-closet consists of the following parts :

1. The closet proper, consisting of the basin, and a trap, and
2. The flushing apparatus.

1. **The Closet Proper.**—There are several varieties of water-closets, of which the following are the chief ones :—

(*a*) Pan closet.
(*b*) Valve closet.
(*c*) Long hopper closet.
(*d*) Wash-out closet.
(*e*) Short hopper or wash-down closet.

(*a*) *The Pan Closet.*—" It consists of a china basin, shaped like an inverted cone, with its outlet guarded by a movable metal pan which retains water in the basin." On raising a handle the pan falls back into a caste-iron receptacle called the " container," into which the excreta

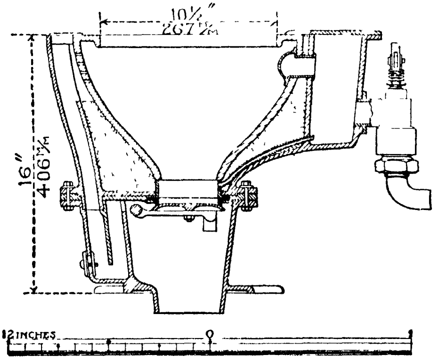


FIG. 19.—VALVE CLOSET.

fall. The bottom of the container is connected by a short pipe to a **D**-trap (D placed sideways) made of lead to prevent the escape of foul air from the soil-pipe. This variety of closet is not used now-a-days, as it is most unhygienic. Its different parts cannot be cleaned, and a certain amount of filth always remains behind in the trap and the container and gives off foul gases. When old the metal pan corrodes and becomes leaky.

(*b*) *The Valve Closet.*—It consists of a stoneware basin with an opening below having a diameter of about 3 in., closed by a water-tight and movable valve fixed by a hinge. The valve opens out on raising the handle and the

excreta are received into a metal box, the lower part of which is connected with a syphon trap leading to the soil-pipe. The closet should be flushed immediately after each visit with plenty of water (2 to 3 gallons) from a cistern, and arrangements made for an after-flush, *i.e.*, for a supply of water into the basin after the handle is released. In case of excessive after-flush the basin may overflow. To prevent this an overflow pipe is attached almost at the top of the basin and is carried down into the valve-box with a syphon bent, which by holding water prevents the escape of foul gas.

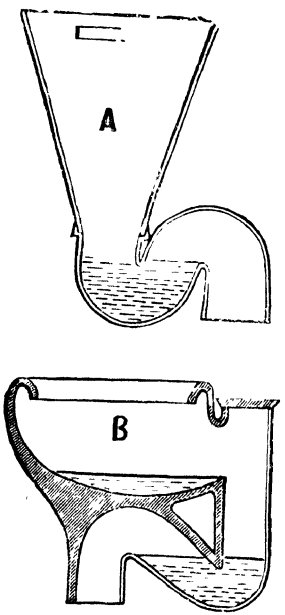


Fig. 20.
A, Long Hopper Closet.
B, Wash-out Closet.

The advantage of this variety of water-closet is that it is noiseless, and has a large exposed surface of water which prevents the fæces from falling upon or adhering to the basin; its principal disadvantage is that the valve is liable to be dislocated by any substance which gets fixed therein, thus allowing the water in the basin to escape and foul air to enter into the closet apartment.

(*c*) *The Long Hopper Closet.* This has no valve and the pan is deep and funnel-shaped. The solid excreta often adhere to the sides, and therefore a great force of water is required to flush it thoroughly.

The *syphonic closet* is an improvement of this variety as it retains a certain amount of water in the pan for the reception of the excreta. Besides, there is a syphon trap with a long ascending arm, and the water contained in this trap is on a lower level than that in the pan. The

contents of the pan are therefore subjected to a force of *vis a tergo* by the flush and a *vis a fronte* by the temporarily induced syphonage in the trap. Still it appears to be unsatisfactory as the foul water often regurgitates into the basin.

(*d*) *The Wash-out Closet.*—In this a certain amount of water is retained in the pan by a ridge. The excreta will have to be flushed out over this ridge, and therefore a powerful flush is required for this purpose. This closet is not without defects, for foul matters are often left behind and the water in the pan is not always enough to cover them.

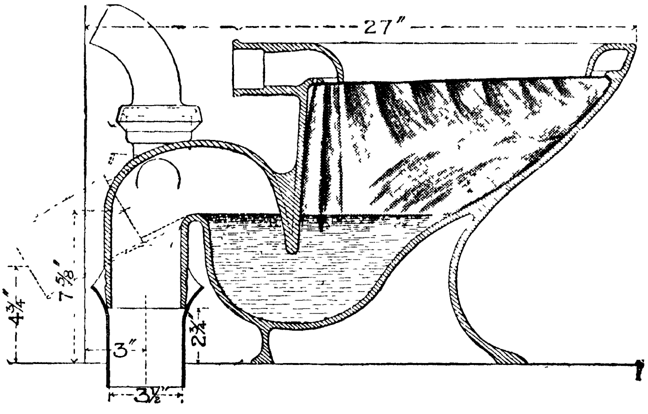


FIG. 21.—WASH-DOWN CLOSET WITH RIM FLUSH, SHOWING P AND S TRAPS.

(*e*) *The Wash-down or Short Hopper Closet.*—This is by far the best and most extensively used. It consists of a short inverted cone, the back of which is almost vertical, so that the excreta may fall directly on the water in the trap without fouling the sides ; with a rim flush it can be easily kept clean.

In selecting a closet preference should always be given to a wash-down or short hopper with a vertical back and a rim flush ; avoiding both the long hopper and wash-out varieties.

In India people use the closet in a squatting posture and therefore the seat arrangement is modified by having two foot rests on either side of the pan proper (*see* Fig. 22). The pan with the trap being placed on a level with the floor of the closet apartment.

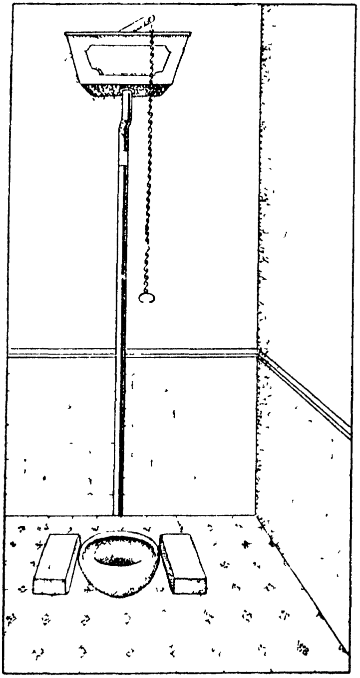


FIG. 22.—WATER-CLOSET.
(Eastern type.)

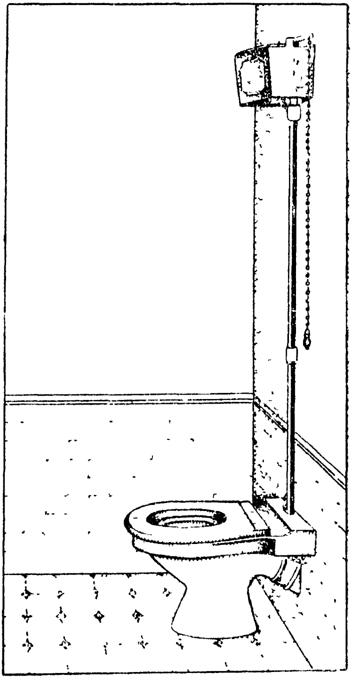


FIG. 23.—WATER-CLOSET.
(Western type.)

2. **The Flushing Apparatus.**—It is important that the water-closet should be flushed immediately after use ; and provision should therefore be made for the storage and discharge of water. Water is stored in tanks or cisterns ; which should be separate for each closet, connected with a main tank placed on the top of the house. The cisterns

are usually made of galvanized iron, and should be placed about 4 ft. or 5 ft. above the basin, and the water delivered by pipes of $1\frac{1}{4}$ in. to $1\frac{1}{2}$ in. in diameter. The pipes should have as few bends and angles as possible. The water is discharged either automatically, or by pedal action, or by a pull of the chain which puts the syphon of the cistern in action. The best type of flushing apparatus should supply three gallons of water each time ; and should fill itself rapidly after being emptied. It should project the water suddenly and forcibly and should supply the same quantity of water every time it is used.

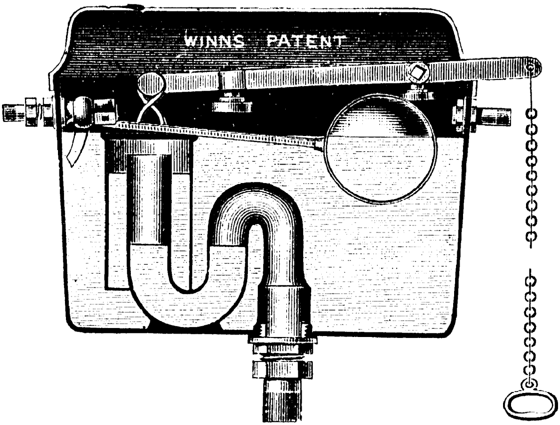


FIG. 24.—SYPHON FLUSHING CISTERN.

Trough Closets.—These closets are suited for places like jails, hospitals, schools, etc. They consist of a long metal, masonry, or earthenware trough placed on an inclined plane under the seats of the closets placed side by side, for the reception of the excreta. The trough retains a certain amount of water by means of a weir at its lower end, and the excreta are expelled by a volume of water, discharged either by an automatic flush, or by an attendant and carried away through a trap placed at the end of the trough. An improvement in trough closet is

made by separate partitions and separate pans attached to one common discharge pipe. The advantages of this type of closets are : (1) one apparatus serves for the use of several persons at one and the same time ; (2) it is cheaper, and hardly ever gets out of order.

B. **Soil Pipes.**—These are circular pipes connecting the water-closets with the drain. They should be either of cast iron, or drawn or milled lead, about eight pounds to the square foot, and laid as straight as possible. Lead pipes are more expeditiously erected and easier of manipulation. They should be exposed right through for ready inspection, and connected with the closet immediately beyond the syphon bend or trap, and carried directly

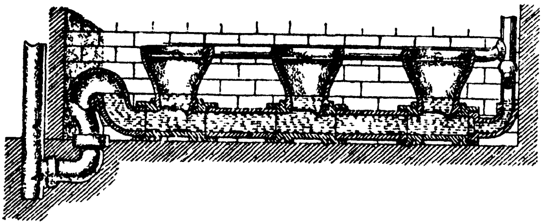


FIG. 25.—TROUGH WATER-CLOSET.

outside the house-wall, to which it should be fixed by tacks. They should have an internal diameter of 4 in., and be carried clear of windows, 6 to 8 ft. above the roof, for the escape of foul gas. The end may either be left open or covered with a wire-gauze dome. (*See* Fig. 33). Whenever possible these pipes should either be fixed on the shady side of the house, or protected by wooden casing, to prevent the joints being damaged by the tropical sun. To prevent oxidation and rusting, iron soil pipes are coated either with magnetic oxide of iron (Barff's process), or they may be dipped in Angus Smith varnish, which is composed of pitch, asphalt, oil and tallow.

The ventilation of soil pipes is necessary, for it not only prevents admission of foul gases but also counteracts syphonage by suction, which, during the transmission of

the contents of some of the upper closets down the soil pipe, causes the water in the trap of one of the lower closets to be drawn off. The ventilation and consequently the anti-syphonic action is ensured by means of a pipe 2 to $2\frac{1}{2}$ in. in diameter fixed on the crown of the trap (on the soil pipe side). Where a series of such ventilating pipes exist, they are generally united either to a separate ventilating main pipe or separately to the soil pipe.

The joints in the case of lead pipes should be "wiped," and in the case of iron ones caulked with lead. The connection between the soil pipe, be it of iron or lead, with the closet pan, *i.e.*, between an earthenware and a metal, should be absolutely water-tight and is best secured by "Doulton's ceramic joint," while that of the soil pipe with the drain by means of a "thimble" or a brass or copper tube about a foot long soldered to the lower end of the soil pipe, while the rim of thimble rests in the socket of the drain pipe and the intervening space is filled with Portland cement.

C. **House Drain.** - A house drain is an underground pipe for carrying away discharges from water-closets (received directly through soil pipes) and waste water from house or compound to the sewer. It is usually constructed of some impermeable material such as glazed stone-ware or iron pipe, the interior of which must be smooth. It should be laid without any angles or bends, with the socket end of the pipe looking towards the point from which the sewage is coming, on a smooth inclined plane to facilitate easy transit of its contents; and if a bend is at all necessary it should be by special curved pipes. A branch drain should join the main drain at an acute angle to lessen obstruction to the flow. It is not always possible in a large building to lay down drains in a uniformly straight line, and in such a case it is desirable to have *manhole chambers* for inspection at every change of direction and to continue the drain through the floor of the chamber by means of half channelled pipes. The joints should be made both air- and water-tight. The pipes should be of sufficient size, and for ordinary houses, the drain should usually be about 4 in. in diameter, but in

big buildings, such as hospitals, hotels, etc., it should be from 6 in. to 9 in. with a fall of about 1 in 50 and a flow of $2\frac{1}{2}$ ft. per second. For all practical purposes the fall should be ten times the diameter of the pipe.

The smaller the drain the better is the flushing and removal of deposit, but in every case it must be large enough to prevent blocking. For all these purposes glazed earthenware pipes are satisfactory and should be laid on a smooth bed of concrete 6 in. deep. When carried under the basement of the house there should be 6 in. of cement concrete all round, and where the collar of the pipe rests, the concrete should be hollowed out and the joints made both air- and water-tight.

Manhole or Inspection Chamber.—This is a square masonry underground chamber, the floor of which is formed by the level of the drain, and rendered perfectly water-tight by lining it with cement. It is provided with an air-tight iron cover, while the ventilation is carried on by a 6-in. pipe. The manhole end of this pipe is opposite the entrance of the drain, while the other end, which is protected by an iron grating and provided with a mica flap valve, is carried a few feet above the ground level and opens into the outside air (*see* Fig. 26 and 33). The valve while admitting fresh air prevents reflux of foul gases. The sewage is conveyed through the manhole by a glazed half-channelled pipe which discharges itself into a trap. The floor of the manhole should form an angle of 30° on either side of the channel. The branch drains which are also made of glazed channelled pipes curved to the proper degree, empty themselves into the main channel. Whenever possible all manholes should be

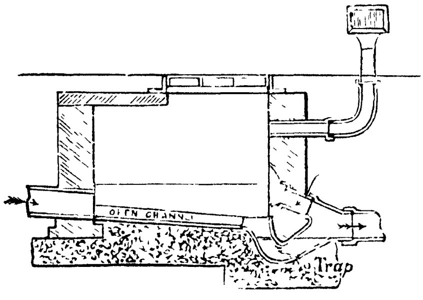


FIG. 26.—MANHOLE CHAMBER.

situated in open spaces or yards and not actually within the building.

Although it is generally held that sewer air is not more harmful than drain air, yet a disconnection of the drain of the building from the public sewer is necessary. This is generally done by having a trap interposed between the house drain and the sewer, and is known as the *intercepting trap* (*see* Fig. 27 and 33). Such a trap, besides having the inlet and outlet ends has two other openings—one near the entrance for acting as an inlet for the air, and other just beyond the syphon bend of the trap for

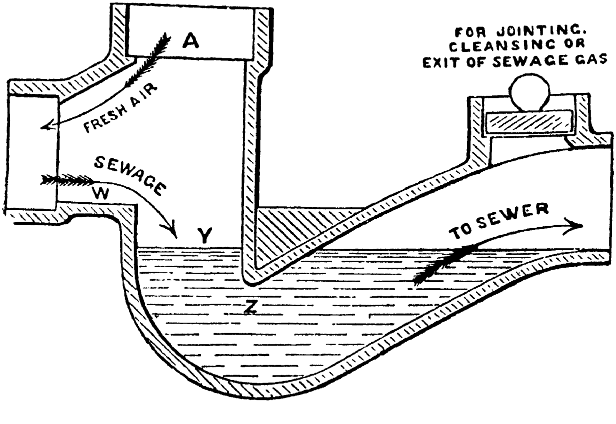


FIG. 27.—INTERCEPTING TRAP.

acting as the clearing eye, and is protected by a lid. The following points, recommended by Parkes and Kenwood, should be observed in selecting such a trap: (1) Where the drain is a 6-in. pipe, the syphon should be a size smaller than the drain; (2) there should be a fall of 2 in. or more from the level of the discharging end of the house drain to the surface of the trapping water; (3) the syphon should provide an adequate seal of 2 in. or 3 in. of water; (4) the inlet to the syphon should be nearly vertical, whilst the outlet rises at an angle of not more than 45°.

Requirements of a good house drain :—

1. A fall that will give good velocity to the current and a smooth internal surface.
2. Well fitting joints to prevent any escape of sewage or gas.
3. Proper flushing arrangement.
4. All branches from the main drain having Y joint; *i.e.* at an acute angle and not at right angle.
5. A good bed of concrete to secure solidity and prevent disjointing of pipes from uneven settling of house foundation.
6. Good ventilation effected by placing a trap outside the house.

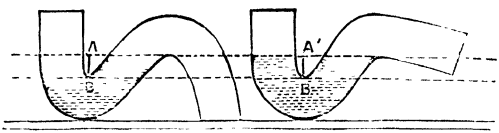


FIG. 28.—S-TRAP AND P-TRAP WITH WATER-SEAL.

D. **Traps.**—A trap is an arrangement in the drain or waste pipe which acts as a barrier to the entrance of sewer air into a house effected by what is called a *water-seal.* A good trap will completely disconnect the air of one pipe from that of another. A trap in its simplest form is a bent pipe which holds up water and prevents air or gas from passing through.

The *water-seal* of a trap is the distance between the level of the water in the trap and the lowest point of its concave upper surface when the trap is in proper position (A B and A′ B′ ; Fig. 28). It should be ventilated and thus not easily unlocked from any cause, and should possess a water-seal of not less than 2½ in.

A trap should be self-cleansing with every flush of water; and have no angles, corners, cracks or projections inside, which might impede the onward flow of any solid matter. A minimum-sized trap consistent with circumstances should always be selected; or it may become a little cesspool

if the size is greater than can be cleaned by an ordinary flush of water. The following are its usual positions :—

1. Under the pan or basin of each water-closet.
2. Near the junction of the house drain with the sewer.
3. In the open air at the level of the ground to receive slop water from baths, lavatories, etc.

Varieties of Traps.—There are many varieties of traps, but the following are the principal ones .—

1. *Syphon Trap.*—It is simply a bent tube, the bend resembling the letter S placed sideways. The water collects at the lower end of S and should stand at least ¼ in. above the top of the curve. It is the best form of trap and maintains a syphonic action as it always keeps a constant level of water. It is usually provided with an opening placed beyond the water seal and intended for an anti-syphonage pipe. Syphon traps are named also as P-trap and S-trap, according as the direction of the outlets is outwards or downwards (*see* Fig. 28).

2. *Flap Trap.*—It is a hinged valve permitting water flow in one direction. It is inefficient and allows sewer air to enter the house.

3. *Mid-feather Trap.*—This consists of a round or rectangular box provided with an inlet tube on one side and an outlet tube on the same level at the other. Water stands up to the lower margin of each pipe with a partition between, which touches the water. This is not self-cleansing.

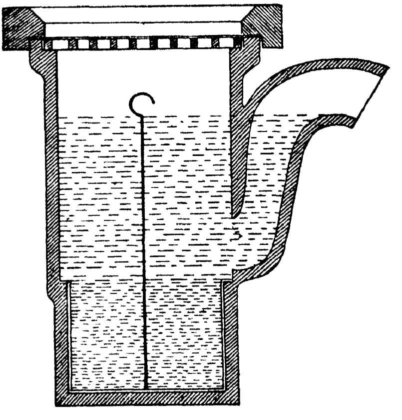


FIG. 29.—GULLY TRAP.

4. *Bell Trap.*—This is a modification of the above, but is equally unsatisfactory as the water-seal is broken when the bell portion is removed.

5. *Gully Trap.*—This is placed in courtyards, especially where rain water and waste water pipes open. It should be placed at a distance of about a foot and a half from any wall, and the surface opening should be as small as possible and protected by a grating to prevent evaporation. As it is possible that mud, other debris and solid particles may be swept into the gully with the inflowing surface water, this trap is so made that these settle at the bottom, which may be removed periodically.

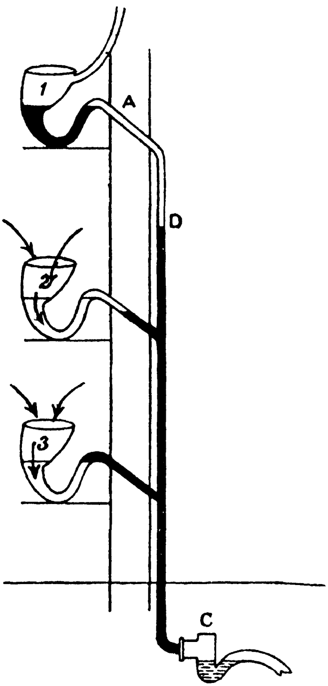


FIG. 30.—Three closets at different levels explaining syphoning of traps.

Under certain circumstances a trap may fail to perform its functions, viz.—(1) Syphon action ; (2) evaporation of the water-seal ; and (3) from deposit of solids or silt.

1. *Syphon action.*—This generally happens where the traps of the soil pipe and closets are unventilated. To understand this examine figure 30 which represents three closets at different levels where the traps are not ventilated. Imagine that each trap of each closet is full of water and the soil pipe and the branch pipes are empty, *i.e.*, the air is locked in the soil pipe between A and C, i.e. between the trap of closet 1, and the unventilated trap of soil pipe C. The effect that follows the use of the upper closet, after flushing, is shown in figure 30. The descending column of water rushes into the soil pipe and compresses the air water-locked at C and leaves behind it a partial vacuum. The outer air

therefore reaches the soil pipe through the way of least resistance, generally through the closets below (2 and 3). The traps of the lower closets, are thus syphoned, and left empty. If the trap be pierced at the top the air pressure will be established at both ends of the leg (*see* fig. 31). It is thus that a ventilating opening to a closet trap breaks the flow and throws enough water back into the body of the trap to preserve the water-seal.

2. *Evaporation of the water-seal* is due to disuse of the trap, thus giving time for evaporation of the water. This generally happens when the house is left unoccupied for sometime.

3. Traps also become useless from being blocked with deposit of solid matter due to imperfect setting, or inefficient flushing, or to insufficient fall in the house drain.

The Testing of Drains, Soil Pipes, etc.

Testing of drains, etc., is always necessary, and is employed not only for new sanitary installations and during the progress of the work to find out if they have been properly constructed, but also in cases of old drains to ascertain whether they are still in good order. The following tests are commonly used :

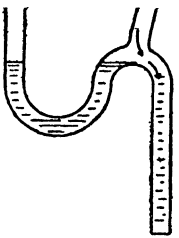


Fig. 31.—Syphon action of trap broken by ventilating opening.

1. *Hydrostatic or Water Test.*—This is especially used in new drainage work. To carry it out plug the lower end of the waste and soil pipes, and each branch fitting with suitable water-tight covers and fill the whole system with water. If the level of the water falls or if the drains do not fill at all, it indicates a defect at some point and the joints should be carefully examined.

2. *The Smoke Test.*—This is usually done by burning either brown paper or by means of a smoke rocket.

This test may be applied either in vertical soil pipes, drain ventilating pipes, or manhole chambers. If there be any leakage or faulty joints, the smoke will issue out and expose the defects. The smoke may also be pumped into the pipes by bellows.

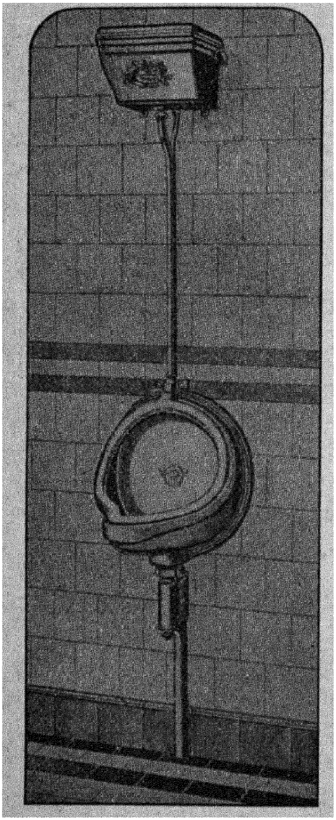


FIG. 32.—URINAL WITH FLUSH.

3. *Chemical Test.*—This test is applied by pouring two or three buckets of hot water with a fluid drachm of some volatile oil down the highest water-closet, or down the pipe from the highest available point. If on examination its peculiar smell is perceived the leakage will be discovered. This test is useless.

4. *Pneumatic Test.*—This is the most recent method, and consists in driving air under pressure by a pump to which is attached a pressure-gauge. The presence of any leakage is evidenced by lowering of the pressure in the gauge, and the point of leakage by a hissing sound.

BATHS, SINKS, AND URINALS

These should always be located in well-lighted and well-ventilated rooms. The material for their construction should be non-absorbent, the best materials for the purpose being enamel, earthenware, stone, slate, procelain, etc. They should be simple in construction and provided with an automatic flushing arrangement. The waste pipe should

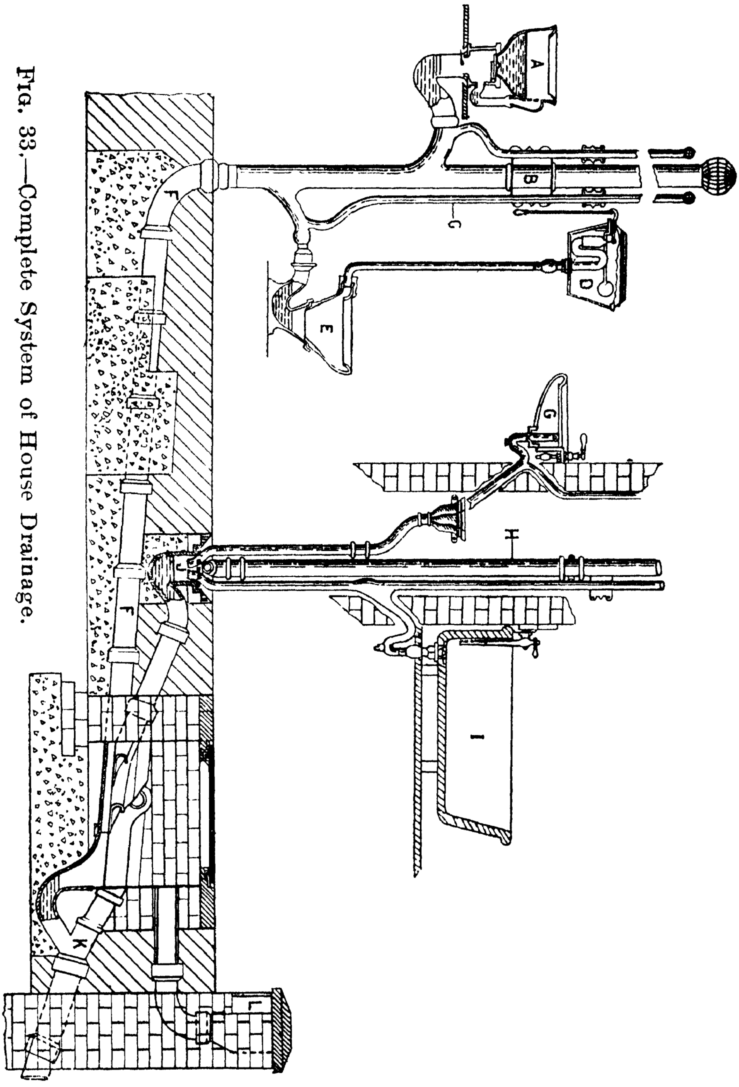


FIG. 33.—Complete System of House Drainage.

preferably be of drawn lead, which is easily fixed and non-corrosive. The urinals should be properly ventilated, trapped, and connected to the soil pipe, or taken separately to the drain. The waste-pipe discharging water from a sink or a bath should be carried separate and made to discharge into the open air over a good water-trap.

[Figure thirty three represents a complete system of house drainage. A and E are two closets which open into the soil pipe B. C is the anti-syphonage pipe ; and D, flushing cistern opening into the closet E. F represents the house drain laid on a bed of concrete. H, rain water pipe ; G, wash basin and I a bath tub. These empty into the gully trap J. K, intercepting trap placed in the manhole chamber intercepting it from the sewer. L, inlet opening for ventilation. The soil pipe and the ventilating pipes are carried above the roof and are protected by wire gauze, they act as outlets].

SEWERS

Sewers are underground conduits designed for the reception and removal of both rain water and sewage by gravitation. This system of sewage removal is known as the "combined system." Two sets of channels are sometimes provided—one for carrying the rain and waste water, and the other—smaller one—for sewage alone. This method is called the "separate system." Those carrying the waste water take the shortest route to the nearest watercourse or river, where they empty themselves, the other set conveys the sewage for final disposal by one of the methods to be presently described.

The *advantages* claimed for the separate system are :

1. The sewers required are of smaller dimensions and so easily flushed, consequently there is less deposit.

2. The sewage is uniform in quality and smaller in quantity.

3. Purification and utilization are effected with less difficulty.

4. In a known population estimation of the total bulk of sewage can be done from the allotment of water per head.

5. Cheaper than the combined system.

The disadvantages are :

1. Two sets of pipes are required for every house and so a wrong connection may be established by mistake.

2. The rain and storm water washes away much that would contaminate a stream.

3. The flushing effect of storm water on the sewage is lost.

These objections are, however, not of much consequence, and the adoption of either plan depends upon the local circumstances. But whatever system is adopted, two objects should be aimed at, viz., (1) removal of sewage by means of impervious pipes, and (2) drainage of subsoil water along the route.

Sewers up to 18 in. in diameter are circular, and made of either iron or glazed stoneware pipes joined together with cement. When of larger dimensions they should be of brickwork and cement. Iron pipes should be coated with Angus Smith solution to prevent corrosion. The best sewer in case where the volume of sewage undergoes great fluctuation is ovoid or egg-shaped with the smaller end downwards. This gives a greater depth of sewage and less contact with the inside walls, consequently there is less friction. Besides, it is much stronger and offers greater resistance to outside pressure.

Earthenware pipes are best laid on a bed of concrete and the joints should be thoroughly cemented, and the inside absolutely smooth. No public sewer should have a diameter of less than 9 in. as then it will carry any article which can come lengthwise around the traps and bends in 4 in. soil pipes and house connection.

Sewers should be self-cleansing and constructed with sufficient gradient. The size should be proportionate to the volume of sewage they have to convey. To prevent deposition in pipes of 12 to 24 in. in diameter the velocity should be $2\frac{1}{2}$ ft. per second, and in sewers of larger dimensions 2 ft. per second. A less gradient is necessary for larger sewers to produce the same velocity as in smaller

ones. The fall should be equable, and all sudden changes in the level should be avoided ; a sewer of 10 ft. in diameter should have a fall of 2 ft. per mile. To calculate the velocity of the flow through sewers the following formula is used :

$$V = 55\sqrt{D \times 2F}$$

V = velocity of flow in feet per minute ;

D = hydraulic mean depth ;

F = fall in feet per mile.

If A = the sectional area of current of fluid, $V \times A$ = discharge in cubic feet per minute. The *hydraulic mean depth* is the sectional area of the current of fluid divided by the wetted perimeter, *i.e.* the portion of the circumference of the sewer in contact with flowing fluid ; in circular sewers running full or half full, it is one-fourth the diameter.

All sewers must be laid with as few bends as possible and the junctions made at acute angles to allow the sewage to enter in the direction of the flow. The junctions from house drains should be so made as to allow the discharge from the house drains to be in the direction of the main current. Curves, if there be any, should be gradual, radius of the curve being not less than ten times the cross-sectional diameter of the sewer ; thus if a sewer be 5 ft. in diameter the curve should never be less than 50 ft.

Inspection, Cleansing, and Ventilation of Sewers

In the sewerage system, it is necessary to provide adequate means for periodical examination, cleansing, and removal of deposit. To meet these ends manholes are to be provided for. These are shafts sunk from the surface of the ground through which a man can descend into the sewer. Branch sewers are made to join the main sewer in these manhole chambers.

Near the upper ends of sewers the flow of sewage is very small, liable not to be able to carry solid filth, thus forming deposits. Similarly in low lying level districts on account of the lack of falls it may be necessary to lay the sewers with very small gradient, and the velocity

therefore is insufficient to prevent deposits. Hence it is desirable to make special provisions for regular flushing to make them self-cleansing by the use of automatic "Flush Tanks". A flush tank is a masonry cistern built in the street above the grade of the sewer, filled by a constantly running stream of water, and emptied by auto-

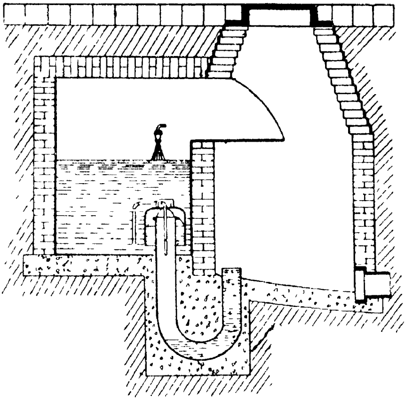


FIG. 34.—FLUSH TANK AND MANHOLE.

matic devices into the sewer. They have a capacity of 150 to 500 gallons, but more the water used better is the flush.

Flush tanks may be combined with a manhole (*See* Fig. 34). This has the advantage of inspecting both the sewer and the tank, and is cheaper.

Sometimes flushing is done by temporarily damming the sewage and then suddenly releasing it when sufficient head is formed. This is done by flushing gates. A hose pipe run into a manhole from a hydrant may often be used with advantage.

The methods most commonly employed during dry weather are either a sudden discharge of a large volume of water through the manholes, or discharging water from large automatic flushing cisterns placed near the head of the sewers.

Ventilation of Sewers.—In every sewer where the sewage is well diluted, the flow rapid and flushing efficient, deposition of sediment does not occur, and the air does not become very foul. But owing to the constant variations of the flow of sewage some deposit forms on the sides, which not only undergoes putrefaction but gives off putrefactive ferments to the sewage flowing by. The tendency to such deposits is less in pipe sewers than in brick ones. The gases evolved by decomposing sewage are combustible, and one should therefore be careful in carrying an unprotected light into a newly opened manhole, old drain, or cesspool. Ventilation of sewers is therefore necessary to dilute such gases.

The simplest way of ventilating sewers is by perforated manhole covers having a tray or dirt-box below to catch dirt, stones, etc. These should be at a distance of about 100 yards. Some of them act as inlets and others as outlets. The air which escapes through these ventilators is rapidly diluted by fresh air and so rendered inoffensive.

Another method is to fix long iron shafts at suitable distances along the length of the sewers. These are carried sufficiently high into the air well above the top of the neighbouring houses for the exit of sewage air or gas into the atmosphere. Street gullies must be efficiently trapped to prevent mud and sand from entering the sewer and the escape of sewer air.

Disadvantages of Sewers.—1. Sewers being closed conduits may cause effluvia to enter into houses ; but if they are properly constructed, flushed, trapped, and ventilated this may be prevented.

2. Any leakage, etc., may contaminate the nearest water-supply. A sewer may leak for various reasons : from cracked joints or pipes, sinking of foundations, imperfect joining or lying, and by the penetration of roots through faulty joints and cracks.

Outfall Sewers.—In every case an outfall sewer must be large and free so that no obstruction to the discharge of sewage may occur. The outfall must be below the level of the water, independent of the tide, and the opening guarded by a valve to prevent the entrance of water.

Where sewage is tide-locked for several hours it should be conducted into especially constructed tanks or reservoirs and then discharged into the river or sea at suitable states of the tide. Sometimes sewage may have to be carried across a river or a valley by bridging, but this is not always practicable when the outfall sewer lies on a lower level. Under such circumstances it should be carried across by the help of an inverted syphon laid in the valley or in the bed of the river. Should the velocity of the current be not sufficient, accumulation and consequent blocking of the syphon with solid matter might take place; therefore, steps must be taken for straining the sewage and occasional flushing of the syphon.

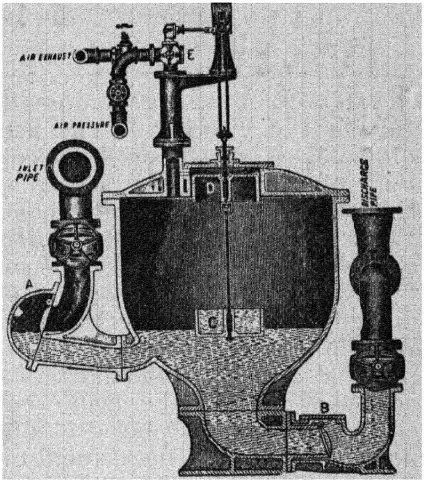


FIG. 35.—THE SHONE EJECTOR.

Pneumatic System of Sewage Removal.—In the case of low-lying areas, where removal of the sewage by gravitation scheme cannot be efficiently carried out for want of a proper gradient, or where tank sewers are productive of nuisance, recourse has to be had either to some system of periodical pumping to raise the sewage to a higher level or to one of the following systems :—

1. *The Shone System.*—In this system the transmission of the sewage is effected by means of compressed air. This is conveyed from a central station to *ejectors* or cylindrical reservoirs placed for the reception of sewage under the ground at different parts of the town. The ejectors are made of varying sizes, from fifty gallons capacity upwards. When the reservoirs become full a

valve opens and admits compressed air by means of a float acting on a counterpoised lever. This propels the sewage forcibly either into a sewer at a higher level or directly into the outfall. The regurgitation of the sewage is prevented by a ball valve in the pipe sewer, and as the ejectors empty themselves the sinking of the float shuts up the valve of the compressed air tube and allows a fresh quantity of air to enter. On a flat surface where a suitable fall cannot be secured this system gives a proper gradient to the sewers and acts admirably.

This system has been adopted in Bombay and Karachi. But in India owing to the heavy rainfall considerable difficulty is experienced in coping with the increased bulk of sewage in the sewers. Under these conditions the ejectors are practically powerless.

2. *Liernur's Pneumatic System.*—In this system there are two sets of pipes; the one smaller in diameter for the removal of waste water; and the other larger (5 in.) in diameter for the removal of sewage proper. The former is discharged into a river or stream, as it is only slightly polluted and the solid matters separated by strainers if necessary; while the latter empties into small closed chambers or tanks placed at different parts of the town under the streets; these small tanks are made to connect with larger ones which again communicate with a central reservoir at the sewage works. The water closets are connected with a receptacle or syphon tank in the basement of the houses; these tanks are themselves coupled up by means of the larger pipes with the various reservoirs underneath the streets. The propulsion of sewage is effected by means of a powerful air pump from a central station, where the sewage is finally sucked into a steam concentrator and then pumped into or disposed of on to land, or made into poudrette. This system, besides being complicated, does not dispose of waste and slop waters, for the removal of which special conduits are required, and there is also possibility of the pipes being clogged with fæcal matter. But in low-lying places where suitable sewer gradients are difficult to secure there is every likelihood of the system being a success.

CHAPTER XIII

DISPOSAL OF SEWAGE

THE primary object in the disposal of sewage consists in changing the different organic matters from the unstable form in which they exist to stable chemical compunds. This result is obtained by the action of microorganisms. The average sewage consists mainly of water with variable quantity of solids and liquids representing the waste products of the community. The character however is very variable depending upon the amount of water consumption, admission of rain water, the character of the effluent from different industries, etc.

The final or ultimate disposal of sewage in either the dry or wet system is a matter of the utmost concern to the sanitarian ; for upon the efficiency with which sewage is disposed of depends largely the general health of the people. Possibilities of its acting as a source of danger to the public, in Western countries, are rather remote, inasmuch as almost every town or village has a separate filtered water-supply. But in India things are different : in villages the water-supply is almost always scanty, and the people generally have recourse to any available source of water, and consequently the pollution of a tank, river, or stream is a matter of great consequence affecting, as it does, the health of the community.

The chief methods of disposal of sewage are mainly (*a*) *Dilution*, and (*b*) *Purification.*

A. Sewage Disposal by Dilution.—This is the readiest method of sewage disposal, and provided the dilution is sufficient it is the proper method. But there must be a volume of water sufficient to permit of aerobic bacterial action which will effect a complete break down of the organic matter and at the same time will not destroy fish

life, *i.e.*, the oxygen content in the stream should not be materially reduced. The current must be sufficient to prevent silting up of the stream, and there should not be any possibility of depositing floating materials on the shore.

In England the method of discharging sewage into the river was practised before, but the conditions become so bad with the small stream and large tributary population that a law was passed prohibiting the pollution of rivers, and several Commissions were appointed by the Government to study the problem. In fact the Commission declared that the proper method of purification of sewage was by distributing on to land, and distribution of sewage by *broad irrigation* was carried out extensively in England. Sewage should not be discharged into any river in India where the dangers are even greater than in any of the Western countries. Under certain conditions the sewage may be discharged without a preliminary purifying treatment into the sea provided it is discharged well below the ebb-tide flow, so that it may at once be carried away from the shore and diluted by a very large volume of water. If it is at all discharged into a river it must be purified before being so disposed of.

B. Sewage Disposal by Purification.—The different methods of sewage purification may be described as follows :—

1. **Intermittent Downward Filtration.**—By this method sewage is purified by the action of the soil which acts as a mechanical filter, and for this purpose a porous soil should always be selected. In the words of the Royal Commission on Metropolitan Sewage Discharge, filtration means "the concentration of sewage at short intervals, on an area of especially chosen porous ground, as *small* as will absorb and cleanse it ; not excluding vegetation, but making the produce of secondary importance. The intermittency of application is a *sine qua non* even in suitably constituted soils, wherever complete success is aimed at." But for this purpose the same soil should be used on the intermittent principle, *i.e.* should have alternate work and rest. The purification is chiefly

effected by soil bacteria or the nitrifying organisms which exist in large numbers in the superficial layers of all soils, particularly in lands rich in organic matter. These organisms require air and oxygen for their development and by feeding on the organic substances of the sewage cause their oxidation. For successful filtration suitable land must be prepared after the fashion of large filter beds, viz.—

1. The bottom of the bed should be efficiently drained by means of porous drains laid 6 ft. below and 10 ft. apart; over this are placed large broken stones, gravel and on top the natural porous soil.

2. The surface of the land must be properly sloped to allow the sewage to spread over the whole area.

3. The sewage should be distributed by surface channels, and the land divided into blocks, each one being irrigated for six hours and allowed to rest and aerate for eighteen hours. By this means the soil is prevented from becoming clogged and re aeration is established.

The land may conveniently be laid out in ridges and furrows, and cultivation may be carried on the ridges while sewage is permitted to flow down the furrows. The effluent which comes out of the subsoil drain is pure, and does not putrefy, and can be discharged into any river or stream. This method is simple and efficient where plenty of suitable soil is available. One acre (about three bighas) of filter bed, if especially prepared, will dispose of the sewage of about 3000 persons.

2. **Broad Irrigation or Sewage Farming.**—This is adopted where suitable land is available in the neighbourhood of a town and is the oldest type of scientific purification of sewage. In the interpretation of the Royal Commission on Metropolitan Sewage Discharge, broad irrigation means "the distribution of sewage over a large surface of ordinary agricultural ground, having in view the maximum growth of vegetation (consistently with due purification) for the amount of sewage supplied." The soil should be reasonably porous, and the land selected low enough to allow the sewage to flow by

gravitation. It may, however, be necessary to under-drain the land, if the soil be not very porous, to carry away the excess of effluent to the nearest watercourse. The sewage must be discharged on to the land in a fresh condition and the coarse portions removed by precipitation or sedimentation. Irrigation of sewage should not be continuous, but must be intermittent, so that aeration of the soil can take place during the period of intermission. The land is laid out on the ridge and furrow system and the sewage flows down the centre of the ridge towards the furrow. Ordinarily one acre of land is required for about 100 persons in temperate climates, but if there be a preliminary precipitation, and particularly in India where evaporation is greater, a smaller area would suffice. It has been observed that during the rains it is rather difficult to take care of the sewage and prevent water-logging.

This method can be profitably carried out in India where land is fairly cheap, and even in the neighbourhood of houses without any danger to health. Broad irrigation with subsequent farming has been successfully carried out in Ahmedabad and Karachi. But it is desirable to locate the farms at a fair distance from towns or places of human habitation. By this process about 90 p.c. of the total suspended matter and bacteria can be removed from sewage. The effluent however is putrescible as there has been no change in the remaining organic matter. Immense crops of coarse grass, sugar-cane, plantains, and other vegetables may be cultivated with profit, and no harm could possibly accrue from eating such products. Badly managed farms—where more sewage is thrown than the land can purify, or where the sewage is discharged without any intermission—may cause the ground to become sodden, and by retarding purification create a nuisance.

3. Chemical Treatment of Sewage.—This is effected by the addition of certain chemical agents which act as precipitants and carry down suspended matters with some dissolved organic impurities of the sewage. The clear supernatant fluid called the *effluent* may be further

treated or discharged into any watercourse or on to any field. The *sludge* or the precipitate is then pressed into cakes and sold as manure. The chemicals commonly used for the purpose are :—

1. *Lime* (as lime water).—It combines with the carbonic acid of the sewage forming an insoluble carbonate of calcium and also with some of the organic bases of the sewage ; the precipitate falls to the bottom, forming sludge. But if lime is added in excess both the sludge and the effluent become alkaline and decompose rapidly, Usually twelve grains of quicklime are required for every gallon of sewage, but the quantity employed varies with the nature of the sewage. This method though simple and cheap is ineffective.

2. *Sulphate of Aluminium.*—This causes a flocculent precipitate which entangles and carries down most of the suspended organic matters. Lime may also be combined with alum in the proportion of five grains of each to every gallon of sewage.

3. *Protosulphate of Iron.*—This salt is a powerful antiseptic, and when added to alkaline sewage or to sewage previously treated with lime, a copious precipitate of hydrated protoxide of iron is formed which carries down suspended organic matters. Two to five grains of this salt are added to each gallon of sewage.

4. *The Amine Process.*—The sewage is subjected to treatment with a mixture of lime and a small quantity of herring brine containing a little methyl-amine. A precipitate forms rapidly which is said to be almost odourless.

5. *The Hermite System.*—In this system the sewage is treated with electrolysed sea-water. By the passage of an electric current through sea-water contained in galvanised iron tanks magnesium chloride is decomposed, forming a disinfecting fluid which, it is claimed, rapidly decomposes fæcal matters in sewage and effectively sterilises it.

6. *The A B C Process.*—In this process alum, blood, clay, and animal or vegetable charcoal are added to the sewage, when a clear flocculent precipitate results. The dried sludge is known as *poudrette.*

The disadvantages of the chemical treatment of sewage are numerous, and it has hardly ever been practised in India, and in places where it has been in use it is rapidly being given up. The sludge which falls to the bottom of the settling tanks is very bulky, and the difficulties and expenditure attending its safe removal and disposal are great. Moreover, the sludge containing organic and mineral matters and about 90 per cent. of water has very little manuring value; and the effluent is not free from pathogenic organisms. In fact the microbes are not removed but the sewage is simply clarified.

4. **Biological Treatment.**—This process, instead of precipitating suspended matters, reduces the complex organic matters present in the excreta into simpler substances by the action of bacteria and other micro-organisms. In fact the disposal of night-soil by trenching, sewage farming, and intermittent downward filtration are really biological methods inasmuch as the ultimate results are obtained by the micro-organisms present in the soil. Within recent years however the biological disposal of sewage has been more thoroughly studied with considerable success, and different methods have been introduced for this purpose. Their main action depends upon the two kinds of microbes present in the sewage, viz. *aerobic* and *anaerobic*. The anaerobic organisms are chiefly concerned in reducing the organic substances of the sewage into simple chemical products, by breaking down, digesting and liquefying them. The albuminoid materials, cellulose and fats are split up into soluble nitrogenous substances, fatty acids, ammonia, gases and derivatives of phenol. This action is encouraged by subjecting the sewage to undergo anaerobic fermentation in the *Septic Tanks*. The aerobic organisms convert by a process of nitrification the ammonical substances into nitrites and nitrates. This action takes place in *Contact Beds* or *Sprinkling Filters*, where the supply of oxygen is increased by subjecting the effluent of the septic tank to pass through especially constructed filters. A still later development is the *Activated Sludge Method*, where the sewage is purified by oxygen provided by driving

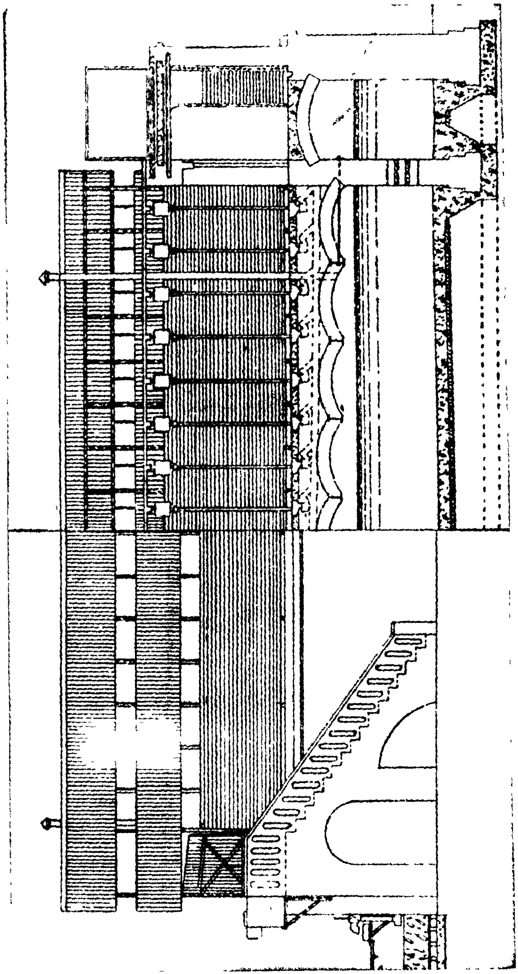


FIG. 36.—SEPTIC TANK LATRINE.

compressed air in tanks in a manner which ensures intimate contact with the crude sewage after fine screening only.

Septic Tanks.—Many varieties of biological installations, such as those of Scott-Moncrieff, Stoddart, Cameron and others, are in existence. This installation was first devised by Cameron of Exeter under the name of the *Septic Tank System*. But the first systematic study of the biological process of the treatment of sewage in the tropics

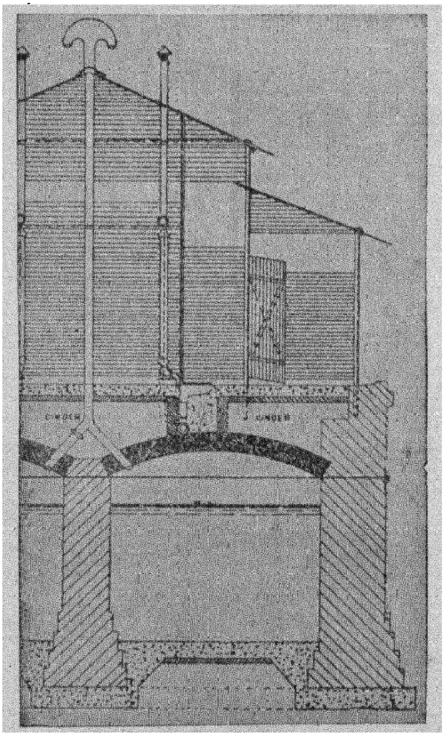


FIG. 37.—SEPTIC TANK LATRINE (Cross-section).

was undertaken by Fowler and Clemesha in 1906, and an ingenious arrangement known as the *Septic Tank Latrine,* which consists of a latrine built actually on the roof of a septic tank, has been introduced. These latrine arrangements are particularly useful for mills, jails, schools, etc.

In this system the combined process depending upon the two groups of organisms, viz. *anaerobic liquefaction* and *aerobic nitrification* is utilised for the purification of the sewage. There is therefore a marked line of demarcation. The anaerobic liquefaction takes place in the septic tank proper, while the aerobic nitrification occurs in the contact bed or sprinkling filters. The sewage, flushed by sufficient water, is first led through one end into a rectangular tank or hollow chamber from which light and air are excluded, and the effluent is let out through a discharge pipe at the other end at a point half-way between the scum and the sludge. The tank should be thin and about five or six times as long as it is broad and must be large enough to retain the flow of sewage from 8 to 24 hours. One measuring 60 ft. by 12 ft. by 6 ft. will meet the requirements of about 2000 users per diem with five gallons flush per user. But a tank capacity of twelve to fifteen gallons per user per day gives the best results. In order to prevent pieces of stones, bricks, or hard lumps of fæces from entering the tank proper, and thereby interfering with its true septic action, arrangements should be made to separate these by a partition. This will cut off a portion of the tank into a small compartment known as the *grit or detritus chamber,* the capacity of which should be about one-eighth of the tank. The connection between this chamber and the septic tank proper, which is also known as the *digestive chamber,* should be at the bottom, through an opening of about 12 in. to 18 in, as it has been found that about 95 per cent. of all fæcal masses float in water, and, therefore, cannot enter the tank. The floor of the chamber should have a slope towards the tank with a depression in its centre for bricks and other heavy substances to lodge. *Ventilation* of the tank and the grit chamber should be efficient, and carried on through ventilating shafts, and provision made for inspection and cleansing by means of manholes. When the sewage enters the tank a scum from 2 to 6 in. thick forms on the surface. Below this scum the process of fermentation goes on with formation of gases.

The action of the septic tank on sewage involves two methods, viz., (1) *anaerobic* or septic tank method, and (2) *aerobic* or contact bed method.

1. *The anaerobic method.*– In this method the anaerobic organisms reduce or breakdown the different complex organic substances into elementary gaseous bodies. They attack and liquefy the sewage in the tank where the fæces are broken down and disintegrated and transformed into a state well adapted for nitrification. In fact, this action of disintegration begins in the grit chamber, and if it is allowed to continue for sometime in a suitably designed chamber very little work will be left for the tank proper. The gases given off by the anaerobic organisms are a mixture of carbon dioxide, methane, hydrogen, and nitrogen and are inflammable which may be utilised for lighting. Little, if any, sludge or deposit is left behind and the ultimate products of decomposition, besides the above-mentioned gases, are ammonia and water. The effluent which is rather inoffensive, though dirty-looking, is drawn off without disturbing the black masses (scum) that float on the surface, and is subjected to further purification in the contact beds by the aerobic bacteria. The sludge accumulates very slowly and consists of indigestible material and includes mineral matter, cellulose, vegetable and elastic fibres, etc. The deposit should never be allowed to exceed 1 ft. in depth and it is advisable to remove it once in three months which should be disposed of by trenching.

2. *The aerobic method.*—In this stage the aerobic organisms construct out of the different gaseous bodies held in solution in the effluent, received from the septic tank, chemical substances of a harmless character. These organisms build out of the nitrogenous gases, first nitrous acid, which forms nitrites, and then nitric acid which forms nitrates by uniting with alkaline or other bases. This process is of importance in biolysis, since these organisms will carry on the purification thoroughly even in the absence of a septic tank, the action of which is merely of a preliminary nature. The best way of getting the effluent into contact with the

bacteria is by passing it through percolating continuous filters, or "contact beds."

A contact bed is a masonry tank on which the effluent from a septic tank is distributed and allowed to remain for a fixed period, generally two to four hours. It acts partly as a mechanical strainer and partly biologically, depending upon the action of aerobic bacteria. Contact beds are filled up with fine hard furnace clinker, *jhama*, or gravel ranging in size from $\frac{1}{4}$ to 2 in. These are not subject to easy disintegration and present a relatively large superficies for aerobic action. They are generally rectangular in shape and may be of any depth, but one with a depth of 3 ft. to 4 ft. gives the best result. The materials should be removed, washed, and replaced periodically. It is important that a contact bed should take not more than half an hour to fill or empty itself, otherwise it would be impossible to arrange the period of rest and contact properly. As in intermittent downward filtration system the contact bed should be so arranged as will enable each bed after four hours work to have a period of rest for eight hours in order to establish re-aeration of the bed, otherwise the organisms will die from deprivation of air.

A *continuous or streaming filter* operates on the same principle as a contact bed and is used for the same purpose, although the method of application of the clarified sewage is different. It consists of a bed of porous material like *jhama*, cinders, etc., scientifically graded from above downwards, over which the effluent is sprinkled through fixed sprinklers, by mechanical travelling sprinklers, dripping trays or tipping troughs to ensure uniform distribution. The necessary chemical changes occur during the passage of the effluent through the filtering medium. When properly designed and started these filters practically require no attention, but their surfaces require to be scraped once a month. It is cheaper, more efficient, and requires less attention than a contact bed.

In some installations an open tank has been substituted for a closed one, on the assumption that the tough scum,

which forms in the septic tank on the surface of the sewage, will also form in an open tank which will prevent the entrance of light and air and will act as a roof of the tank. In practice it has been found to work satisfactorily and therefore this modification has been adopted in Manchester.

The septic tank effluent should not be discharged into a stream from which water is drawn for drinking purposes. It can, however, be satisfactorily disposed of by discharging it on land or into the sea, or by using it for boilers in mills and factories. It has been found that the septic tank effluent contained the eggs and larvæ of hookworm. Tanks that were overworked and filled with sludge showed more larvæ than those that were in proper use. Therefore, where the effluent is discharged into a stream or a river, it is necessary to remove the danger of transmitting water-borne diseases by disinfecting it before being so discharged. This is done by using a definite amount of chloride of lime in solution or chlorine gas, or by electrolytic action.

The following are the requirements of a septic tank installation :—

1. There must be a sufficient supply of water to provide an automatic or occasional flush, sufficient to carry the excrement to the tank, and also to keep the place clean.

2. Under no circumstances should any disinfectants be used, this method takes advantage of the biological action of putrefactive bacteria.

3. The tank should be built in two sections under the names of grit chamber and digestive chamber, separated by an upper and lower baffle wall.

4. There must be plenty of space above the line of the fluid which stands in the tank, to accommodate the "scum " and the gas.

5. There must be water-seal inlet and outlet to maintain the fluid at a definite level and prevent the escape of foul gas, which should be led off by a gas pipe and can be burnt in a mantle. This gets rid of all noxious smell and at the same time lights up the place.

When *starting a new tank* it should be inoculated with about a hundred gallons of sludge and effluent from a neighbouring tank and then filled with water. The work of the tank should be pushed on gradually, and it takes on an average about six months to give a satisfactory effluent.

Activated Sludge Process.—This process is in reality an aerobic method of disposal of sewage and is claimed to be the most satisfactory method yet introduced. It is worked on the same principle as contact beds, but here a much higher standard of efficiency is aimed at. The sewage is intimately mixed with the bacterial culture by agitation, the necessary oxygen being provided by minute bubles of air blown through the mixture and a practically infinite surface of contact is thus produced.

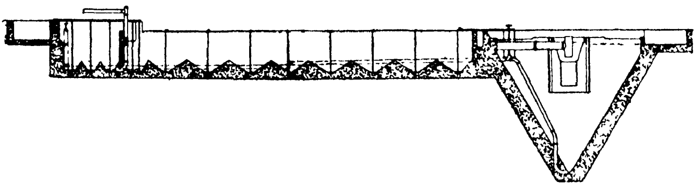


FIG. 38.—SECTION OF ACTIVATED SLUDGE PLANT.

The main action takes place in the aerating tanks (*see* Fig. 39) in the bottom of which are "diffusers" of a special porous material, through which compressed air is passed and atomised, so that it rises in minute bubbles through the sewage. This is continued until all the ammonia in the sewage is oxidised into nitrates. The air is then turned off and the sludge sinks to the bottom. This sludge is the 'activated sludge' and though resembles septic tank sludge is essentially different to it. It is inoffensive, and is an aerobic 'bacterial culture.' If this sludge is left in the tank, the tank is again filled up with sewage, and the aeration is continued then the nitrification takes place more rapidly owing to the presence of this bacterial culture. It takes some weeks to form the necessary quantity of activated sludge for the purification to take place in a minimum time.

The process of purification takes place in two stages. During the first stage the organic matter is broken down and the carbon is converted into CO_2. After this stage the liquid becomes more or less stable, but the process of aeration is continued for a time when during the second stage nitrates are formed. The working is as follows :—

All heavy grit and large floating solids are first removed and the sewage is passed through a rough screen to the circular tank, where the disintegration is effected by

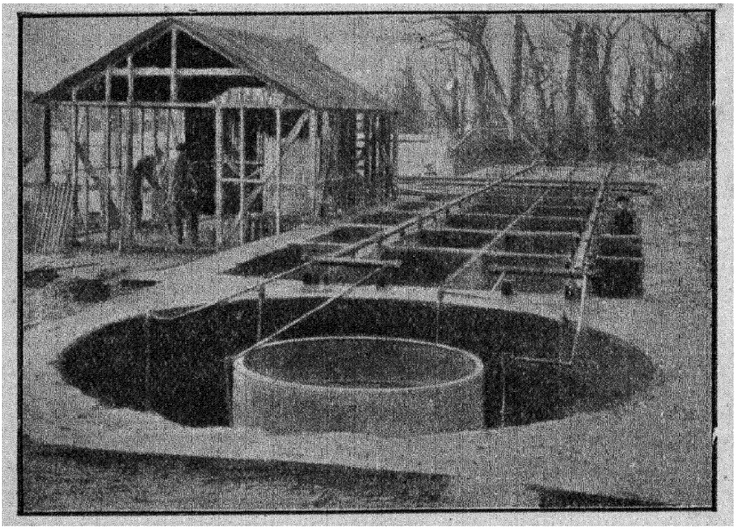


FIG. 39.—ACTIVATED SLUDGE PLANT (Inlet end).

blowing through the sewage minute bubbles of air. This is done by porous diffusers fixed in the bottom of the tank in narrow furrows placed radially. A fine emulsion of air and water is thus formed which rises to the top carrying with it the solids which are broken up mechanically. The sewage now passes through the fine screen into the greese-collecting chamber where any greese is collected at the top of the liquid and trapped, while the

sewage itself is drawn off from the bottom and is passed into the mixing chamber. Here it is mixed with previously aerated sludge and further aerated by means of the diffusers. The volume of the activated sludge added varies from 15 to 16 p.c. according to the character of the effluent desired.

The mixture then passes through the aeration channel where the actual purification takes place. The time required for aeration is 6 to 8 hours, but may be as short as 2 hours or as long as 24 hours. After purification the sewage passes down the feed pipe to the settlement tank. The effluent is drawn off and is run into a suitable outfall.

The following are the advantages of this process :—

1. The effluent is fully oxidised and is clear and free from colloids. Purification is rapid and perfect.

2. Putrefaction is quickly stopped and the system is free from smells and flies.

3. The sludge is inoffensive and forms a valuable manure.

4. A small area of land is sufficient, and a skilled attendant with a small staff can easily manage the work.

5. Owing to the simplicity of the plant, the small tank area required, and the absence of filter beds the capital expenditure is much less.

Two other methods have been advocated of late for the biological disposal of sewage adapted for use in the private houses. They are (1) *The 'Aqua Privy'* and (2) *The 'Antipolo' System* used in the Philippine islands. The "aqua privy" consists of a cylindrical tank having a drowned outlet, and a separate upper piece with which is embodied the seat or foot rest. The tank is filled with water before use and the night soil goes straight into the tank (under the privy seat) where septic action takes place. It is claimed that this system is superior to the ordinary service privy and the chances of infection from water-borne diseases are greatly minimised. The "Antipolo" system of privies have been introduced in the Philippine islands for the sanitary disposal of sewage. It consists of a covered pit, a platform or seat with a pipe

connected to the pit, and a ventilating tube. Experience has demonstrated that by keeping the parts of the 'Antipolo' privy in good repair, the upper part of the pipe connected with the platform or seat clean by occasional scrubbing, and the bottom of the pit just covered with water, the privy will be odourless and its contents thoroughly digested and safely absorbed.

Merits of the different methods of Sewage Disposal.—Speedy and complete removal of all excrementitious matters from the neighbourhood of habitations is the primary object to be aimed at. The dry method is not efficient, as the removal of excreta is undertaken at intervals, and it does not satisfy all the requirements. For large towns the water-carriage system is the only efficient method of removal of night-soil. It should not be discharged into any river or stream, but where suitable land is available either intermittent filtration or sewage farming may be undertaken. By land filtration an effluent is usually obtained which may be discharged into a stream, the water of which is not used for drinking purposes. Irrigation, besides giving the above-mentioned results, has the advantage of rendering the land more fertile by holding up certain ingredients having some manurial value. Where land is not available the sewage should be treated biologically. This is by far the best method, as it is based on a solid scientific principle, besides being thoroughly efficient and economical. But the effluent obtained by this treatment is not, as a rule, harmless, and therefore cannot be permitted to run into any watercourse without subjecting it to a land or special sand filtration or chemical treatment.

Analysis of Sewage

Equal quantities are taken every hour and mixed, and a sample is then taken. The bottle containing the sample should be completely filled, and examined at once, or kept in an ice chamber.

The Incubation Test is performed by placing a small bottle, with a ground glass stopper, filled with sewage, in

the incubator at 37°C. and allow it to stand for a week. If the sewage has not become offensive during the period and nitrates are still present, it may be considered good.

Incubation Test (Putrescibility Test) by Permanganate (Scudder).—A small well stoppered bottle (of about 125 c.c capacity) is completely filled with effluent, the stopper firmly inserted, and the liquid incubated at 80°F. (26.6°C.) for five days. At the end of this time the oxygen absorbed from permanganate in three minutes is again determined. If either the same quantity of permanganate or less of it is now required than in the corresponding estimation in the original sample, the liquid has withstood incubation; if, on the other hand, more is needed, it has not.

Methylene Blue Test.—In the majority of cases it will be found that if an effluent is not satisfactorily purified it will, if faintly coloured with methylene blue and incubated at 37°C. for about six hours, cause the colour to be discharged; and in the majority of cases, on the other hand, if the colour persists, it is an indiction that a fair amount of purification has been accomplished.

As a preliminary test, therefore, the following method may be useful:

A 0.05 per cent. aqueous solution of methylene blue is made up, and 1 c.c. or so, as may be required in order to obtain a *faint* blue coloration, is added for each 50 c.c. of the sample. The coloured sample is placed in a glass-stoppered bottle which is completely filled, carefully excluding air bubbles, incubated at 37°C. and the time noted which elapses before decolorisation takes place.

To calculate the percentage amount of purification effected from the differences between the "albuminoid ammonia" and "oxygen absorbed" figures of the original sewage and those of the effluent: For this purpose the figures of the original sewage are taken as 100.

Example.—The albuminoid ammonia of the original sewage $=0.76$ part per 100,000 and that of the purified effluent $=0.16$. The difference is $(0.76-0.16)=0.6$. The percentage purification would therefore be $\frac{100 \times .06}{0.8} = 75$.

Estimation of Dissolved oxygen :

The *rate of absorption* of dissolved oxygen by a sample of sewage or effluent affords a measure of the readiness with which it will deprive a stream of its dissolved oxygen when the two are mixed. There are several methods for determining the dissolved oxygen in water, but Winkler's process, which is perhaps the most simple, is described here :

A mixture is made of nine volumes of tap water and one volume of sample, (100 c.c. of sewage made up to 1000 c.c. with tap water) and three bottles of about 300 c.c. capacity (8 ounces) completely filled with the mixture. The dissolved oxygen is determined in one bottle after standing for about one hour, in the second bottle after incubation for about 24 hours, and in the third after incubation for 48 hours or longer.

In carrying out the experiments the following reagents are required :

(*a*) A standard solution of manganous chloride (made by dissolving 80 grammes of manganous chloride in 100 c.c. of distilled water).

(*b*) Solution containing 30 per cent. of caustic potash (KOH) to which 10 per cent. potassium iodide has been added.

(*c*) Concentrated hydrochloric acid.

(*d*) Standard solution of sodium thiosulphate (1 c.c.= 2 mgrm. of oxygen).

Process.—1 c.c. of (*a*) is carefully added by means of a long pipette to the sample in the bottle and similarly 1 c.c. of (*b*). The stopper is pushed in and the mixture well shaken and allowed to stand for about 10 minutes. 2 c.c. of concentrated hydrochloric acid (*c*) is then carefully added and the stopper replaced and the mixture shaken and allowed to stand with occasional shaking till the whole of the manganous precipitate is dissolved. The solution is then poured into a basin and the free iodine present is titrated with standard thiosulphate solution (using starch solution as an indicator). The iodine liberated is thus equivalent to the dissolved oxygen.

Characters of a good Sewage Effluent.—A good sewage effluent should possess the following characters :

1. It should have no fæcal smell, and a small living fish when kept in it should not readily die.
2. There should be no marked deposit.
3. The amount of organic ammonia present should not exceed 0.1 part per 100,000.
4. The amount of oxygen absorbed in 4 hours at 80°F. should not be more than 1.5 parts per 100.000.
5. The amount of suspended matters should not be more than 3 parts per 100,000.
6. When incubated in a closed bottle for a week at 80°F. should not show any sign of putrefaction (as evidenced by the production of gases, foul smell, etc.)

CALCUTTA MUNICIPAL ACT OF 1923

Schedule xv

Rules as to Drains, Privies and Urinals

Drains

2. Every underground house-drain shall consist of good sound pipes made of glazed stoneware or other suitable material, and shall have water-tight joints made of Portland cement or any other cement.

3. Every such house-drain shall be of adequate size, with an internal diameter of not less than —

(*a*) six inches between the master-trap and the sewer, and

(*b*) four inches at all other places.

4. No such house-drain shall be so constructed as to form in any of such drains a right-angled junction, either vertical or horizontal, and every branch drain or tributary drain shall be joined to another drain obliquely, at an angle of not less than one hundred and thirty-five degrees, in the direction of the flow of such other drain.

5. Every such house-drain shall be—

(*a*) laid upon a bed of good concrete of such width as may be approved by the Executive Officer, and not less than six inches thick,

(*b*) covered for half its depth with concrete not less than four inches thick, and

(*c*) so constructed as to have a proper fall.

7. (1) In every such house-drain a suitable trap shall be provided.

(2) Such trap shall be placed—

(*a*) within the premises, or,

(*b*) with the approval of the Corporation and on payment of such fees as may be prescribed by the Corporation, in the footpath or (if there is no footpath) in the roadway adjacent to the premises, and

(*c*) at a point as distant as may be practicable from the premises and as near as may be practicable to the point at which the drain is connected with a municipal sewer.

9. The soil-pipe of every connected-privy or connected-urinal shall—

(a) be at least four inches in diameter,

(b) be fixed outside the privy or urinal, or outside the building in which the privy or urinal is situated, and be continued upwards without any diminution of its diameter,

(c) be of such height and be so placed as to afford, by means of the open end of the pipe, a safe outlet for sewer air,

(d) whenever practicable, be so constructed as to avoid any bend or angle, and

(e) be so constructed as to have no trap between the pipe and the drains with which the privy or urinal communicates, and no trap (other than such trap as necessarily forms part of the apparatus of the privy or urinal) in any part of the pipe.

11. (1) The following pipes in any new building, namely :—

(a) the waste-pipe from any bath-sink (not being a slop-sink constructed or adapted to be used for receiving sewage) or lavatory,

(b) the overflow-pipe from any cistern or from any safe under a bath or connected-privy or connected-urinal, and

(c) every other pipe for carrying off waste water,

shall be taken through an external wall of the building, may, if the Executive Officer so directs, be provided with a suitable trap, and shall be so constructed as to discharge into the open air over a channel leading to a trapped gully-grating at least eighteen inches distant from that end of the pipe from which the water issues.

17. Except with the written permission of the Corporation and in conformity with such conditions as may be prescribed by the Corporation, either generally or specially, in this behalf, no drain shall be so constructed as to pass beneath any part of a building.

18. The following provisions shall be observed when any drain is, with the permission of the Corporation granted under rule 17, constructed so as to pass beneath a building namely :—

(1) the drain-pipe shall be of iron or such other material as the Executive Officer may approve ;

(2) the drain shall be so laid as to leave, between the top of the drain at its highest point and the surface of the ground beneath the building, a distance of not less than the full diameter of the drain ;

(3) the drain shall be laid in a direct line throughout the whole distance beneath the building ;

(4) the drain shall be completely embedded in, and covered with, good and solid concrete at least six inches thick all round ;

(5) adequate means for ventilating the drain shall be provided (where necessary) at each end of such portion thereof as lies beneath the building.

PRIVIES AND URINALS

21. (1) No privy should be placed in the space required by this Act to be left at the back of the building—

(a) unless the total height of the privy does not exceed eleven feet ; and

(b) if the privy is a service-privy unless there is a space of at least four feet between the nearest wall and the service aperture of the privy.

(2) No service-privy or service-urinal, situated in, or adjacent to, building shall be placed at a distance of less than six feet from—

(i) any public building or

(ii) any building which is, or likely to be, used as a dwelling place, or as a place in which any person is or is intended to be, employed in any manufacture, trade or business.

22. (1) No service-privy or service-urinal shall be placed on any upper floor of the building :

(2) The Corporation may, by written notice, require the owner of any building to convert any service privy into a connected privy.

25. (1) A drain shall be provided for every service-privy and every service-urinal ;

(2) such drain shall be constructed of some impervious material and shall connect the floor of the privy or urinal,—

(*a*) with a drain communicating with a municipal sewer ; or

(*b*) if permitted by the Corporation, with an impervious cess-pool the contents of which can be removed to a municipal sewer either by hand or by flow after filtration.

26. (1) The floor of every privy and every urinal shall,—

(*a*) be made of one of the following materials, that is to say, glazed tiles, artificial stone or cement, or

(*b*) if no such direction is given, be made of thoroughly well burnt earthen tiles or bricks plastered with cement and not merely pointed with cement, and

(*c*) be in every part at a height not less than six inches above the level of the surface of the ground adjoining the privy or urinal.

27. The walls and the roof (if any) of every privy or urinal shall be made of such materials as may be approved by the Corporation : provided that

(*a*) in the case of the service-privies and service-urinals, the entire surface of the walls below the platform shall either be rendered in cement or be made as prescribed in clause (*a*) or (*b*) of rule 26 ;

(*b*) in the case of connected-privies and connected-urinals the walls shall, up to a height of at least twelve inches above the platform be made as prescribed in clause (*a*) or (*b*) of rule 26.

31. Every connected-privy and connected-urinal situated in a building shall be separated by a masonry wall from kitchen, habitable rooms and rooms in which any person is or is intended to be employed in any manufacture, trade or business.

32. (1) Every connected-privy shall be provided with a suitable water cistern, so arranged as—

(*a*) to discharge direct into the pan of the privy not less than three gallons of water each time the cistern is used, and

(*b*) to prevent water being drawn from the cistern for any other purpose.

(2) All waste-pipes and overflow-pipes attached to such cisterns shall terminate in the open air and be cut off from all direct communication with any drain.

34. Every connected-privy and connected-urinal shall be provided with an air-tight water trap immediately below the pan.

35. Every connected-privy and connected-urinal shall be provided with a syphon trap which shall be proof against syphonage.

36. No 'container' or other similar fittings shall be placed under the pan of a connected-privy or connected urinal; and no trap of the kind known as "D-Trap" shall be used with any such privy or urinal.

37. (1) Every connected-privy and connected-urinal shall be provided with a soil-pipe for carrying sewage to a municipal sewer.

(2) Such soil-pipe must have air-tight joints, and, if it be placed above ground, shall be made of metal approved by the Executive Officer.

(3) Such soil-pipe shall have in addition to the trap prescribed by rule 34, a trap placed at some point between the privy or urinal and the sewer.

(4) Such soil-pipe shall be ventilated by direct communication with the open air, and if the privy or urinal is situated in a building, the pipe must be carried outside the building.

BENGAL MUNICIPAL ACT

Sewage, Offensive Matter, Rubbish, Privies and Drains

Sec. 186.—The Commissioners shall provide all establishments, cattle, carts, implements required for the removal of sewage, offensive matter and rubbish.

Sec. 187.—The Commissioners at a meeting may appoint the hours within which it shall be lawful to remove sewage and, offensive matter and the manner in which the same shall be removed, and may provide places convenient for the deposit thereof and may require the occupiers of houses to cause the same deposited daily or at other stated intervals, in such places, and may remove the same at the expense of the occupier if the occupier thereof fails to do so in accordance with this Act.

Sec. 189.—The Commissioners at a meeting may appoint the hours within which only every occupier of any house or land may place rubbish on the public road adjacent to his house or land in order that such rubbish may be removed by the Commissioners and the Commissioners may charge such fees as they may think fit in respect of the removal of such rubbish.

Sec. 190.—All drains, privies and cess-pools shall be subject to the inspection and control of the Commissioners.

Sec. 191.—The Commissioners, or any officer authorised by them in that behalf, may inspect all privies, drains and cess-pools at any time between sun rise and sun set after six hours notice in writing to the occupier of any premises in which such privies, drains, or cess-pools are situated, and may if necessary cause the ground to be opened where they or he may think fit for the purpose of preventing or removing any nuisence arising from such privies, drains or cess-pools; and the expenses thereby incurred shall be paid by the owner or occupier of such premises.

Sec. 193.—The Commissioners may provide and maintain in sufficient numbers and in proper situations, common privies and urinals for the separate use of each sex, and shall cause the same to be kept in proper order and to be properly cleansed.

Sec. 194.—The Commissioners may license such necessaries for public accommodation as they from time to time may think proper.

Sec. 197.—All existing public sewers, drains and other conservancy works shall be under the direction and control of the Commissioners, who shall have power to construct any further works of that nature which they may consider necessary.

Sec. 217.—Any person who, in any municipality—(1) being the occupier of a house in or near a public road, keeps, or allows to be kept, for more than twenty-four hours, or for more than such shorter time as may be prescribed by a bye-law, otherwise than in some proper receptacle, any dirt, dung, bones, ashes, nightsoil or filth, or any noxious or offensive matter in or upon such house, or in any out house yard or ground attached to and occupied with such house, or suffers such receptacle to be in a filthy or noxious state, or neglects to employ proper means to clean the same; or (2) keeps any public necessary without a license, or, having a license for a public necessary, suffers such necessary to be in a filthy or noxious state or neglects to employ proper means for cleansing the same, or

(3) being the owner or occupier of any private drain, privy, or cess-pool, neglects or refuses, after warning from the Commissioners, to keep the same in a proper state;

shall, for every such offence, be liable to a penalty not exceeding fifty rupees.

Sec. 224.—The Commissioners may require the owners or occupiers or the owners and occupiers of any land, within fifteen days, to repair and make efficient any drain, privy or cess-pool or to remove any privy or close any cess-pool which is situated on such land.

Sec. 225.—Every person constructing a privy shall have such privy shut out by a sufficient roof and wall or fence from the view of persons passing by, or residing in, the neighbourhood.

Sec. 230.—No person shall, without the written permission of the Commissioners, construct or keep any latrine, urinal, cess-pool, house-drain, or other receptacle for sewage or other offensive matter within fifty feet of any public tank or water course, or a tank or water course which the inhabitants of any locality use.

Sec. 231.—No person shall, without the written permission of the Commissioners, construct a privy with a door or trap door opening on to any road or drain. The Commissioners may require any owner or occupier upon whose land any such privy exists to remove the same within eight days.

Sec. 270.—Whoever, within a municipality,

(1) without the permission of the Commissioners, throws or puts, or permits his servants to throw or put, any sewage or offensive matter, on any road, or earth, rubbish, sewage or offensive matter into any sewer or drain belonging to the Commissioners, or into any drain communicating therewith; or

(2) causes or allows the water of any sink, sewer or cess-pool, or any other offensive matter belonging to him or being on his land, to run, drain or be thrown or put upon any road, or causes or allows any offensive matter to run, drain or be thrown into surface drain near any road; or

(3) constructs a latrine, urinal, cess-pool, house-drain or privy in contravention of the provisions of sections 230 and 231; or without the written permission of the Commissioners, digs or makes, or causes or

suffers to be dug or made, any excavations, cess-pool, tank or pit, in contravention of the provisions of section 232 ;

shall be liable, for every such offence, to a fine not exceeding twenty-five rupees.

Sec. 272.—Whoever, within a municipality,

(1) without the written consent of the Commissioners previously obtained, makes or causes to be made, or alters or causes to be altered, any drain leading into any of the sewers or drains vested in the Commissioners by this Act ; or

(2) constructs any branch drain, privy or cess-pool contrary to the directions and regulations of the Commissioners or contrary to the provisions of this Act, or, without the consent of the Commissioners, constructs, re-builds or unstops any drain, privy or cess-pool which has been ordered by them to be demolished or stopped-up or not to be made ;

shall be liable, for each such offence to a fine not exceeding fifty rupees.

Sec. 320.—In any municipality to which the provisions of this part (*i.e.* Part IX) shall have been extended in the manner prescribed by section 222, the Commissioners may issue a notice declaring that, from a date to be specified in such notice, they will maintain an establishment for the cleansing of private privies and cess-pools within the limits of the municipality, or any part thereof ; and the Commissioners shall make suitable provision accordingly.

Sec. 332.—If the Commissioners think that any latrine or additional or common latrine should be provided for any house or land within the limits of the municipality, the owner of such house or land shall, within fourteen days after notice given by the Commissioners, or within such longer times as the Commissioners may for special reasons allow, cause such latrine to be constructed in accordance to the requisition of such notice ; and if such latrine is not constructed to the satisfaction of the Commissioners within such period, the Commissioners may cause the same to be constructed, and the expenses thereby incurred shall be paid by the owners, and shall be recoverable as provided in section 322.

Sec. 350.—The Commissioners of any municipality may from time to time, at a meeting which shall have been convened expressly for the purpose, and of which due notice shall have been given, frame such by-laws as they deem fit, not being inconsistent with this Act, or with any other general or special law, for—

(*b*) regulating the use of, and the prevention of nuisances in regard to, public water supply, bathing and washing places, streams, channels, tanks and wells ;

(*c*) regulating the disposal of sewage, offensive matter, carcases of animals and rubbish, and the management of privies, drains, cess-pools and sewers ;

(*d*) regulating cremations and burials and the disposal of corpses ; etc., and may by such by-laws impose on offenders against the same such reasonable penalties as they think fit.

CHAPTER XIV

DISPOSAL OF THE DEAD

STRANGE indeed are many of the ceremonies attending the disposal of the dead in different parts of the world, and following the natural order of things, the more primitive the nation the more primitive its methods. The rudest mode now prevalent is that of simply leaving the body exposed, but the ways of exposure vary considerably. The Wanyamwesi in Africa, carry their dead into the forest to be devoured by beasts of prey, while some of the tribes of Guinea throw the corpse into the sea. The Kamtchadales keep dogs to consume their dead. The Parsees place their dead in a round tower, called the Tower of Silence.

Burial, of course, has many different forms, the simplest of which is perhaps the piling of stones or thorns over the body to keep off wild beasts. *Cremation*, perhaps, is an earlier custom than that of burial in the earth, *embalming*, or *drying* the body by suspending it from a tree.

Safe disposal of the dead in such a manner as not to affect the public health is an important sanitary problem. Customs associated with their disposal are too well established. Any modification, therefore, in the direction of improvement—whenever the existing methods are opposed to sanitary ideals—should be made "having due regard to the sentiment of the relations and the populace generally and to the religious observances peculiar to each sect." The method of removal of the dead for disposal is no less important. The usual practice in India is to carry the body on a *charpoy* ; but with certain poor classes it is often carried tied on to a piece of bamboo. Moreover, the bodies are not always properly covered. Such a practice is not only unsightly but unhygienic.

Cremation or Burning

Cremation may be said to have been the general practice of the ancient world, with the exception of Egypt, where the bodies were embalmed: Judæa, where they were buried in sepulchres; and China, where they were buried in the earth. Cremation is the most satisfactory method of disposal of the dead, and is the old-established custom with the Hindus, who burn the body on a pyre in the open air. By this method the body is reduced to a small quantity of odourless ash within about three hours. The bodies are cremated on the banks of rivers, and in the absence of a river, on the bank of some tank. The usual fuel is wood (ordinary *soondry* or *goran*), and costs about six rupees (ten shillings). The quantity of fuel required to completely consume the corpse of an adult is about five maunds or 400 lbs. The bodies are as a rule so covered by wood that very little can be seen. The smell is hardly perceptible at a short distance, and if the place is enclosed by a wall the nuisance to the neighbourhood is reduced to a minimum. When any special kind of wood, *e.g.*, sandal wood, is used, the cost becomes proportionately higher.

In large cities cremation acquires an increased importance on account of the promptitude with which dead bodies may be disposed of during epidemics, as fire removes all traces of contagion that might remain in a grave-yard. A burning ground also occupies less space. The smoke and smell coming from a burning ground, especially when it is busy, indicate that the temperature of the fire is insufficient, and heat is being wasted. An open fire cannot concentrate its heat on a body, and the smoke proves that the air supply is defective. To consume a body rapidly, completely, and without offence within a city the fire should reach its highest temperature before the body is placed in it, and this is only possible when it is enclosed in a properly constructed furnace.

The chief objection to cremation is that it affords facilities for concealing evidences of crime. By making proper arrangements for examination of the dead bodies,

or by insisting on the production of death certificates from qualified medical men, such an objection may be overruled. Poisons, like copper, arsenic, etc., might be detected from the ashes or unburnt pieces of wood. It is desirable, whenever possible, that burning places should be at least 500 ft. away from any inhabited locality.

Cremation is gradually becoming popular with the Europeans, and a crematorium has been established in Calcutta. The most perfect cremation furnace should consist of a bed of finely broken quartz, seven feet long and twenty-eight inches wide, supplied from beneath with a mixture of gas and air, which when properly adjusted burns without visible flame, rendering the quartz bed nearly white hot. The temperature is upwards of 3,600°F. This heat will decompose water to its elements and consume all organic matter. The furnace should be enclosed with an opening above to let out the invisible and odourless products of combustion. The process will last for about half an hour and the residue left will be a small quantity of white lime from the bones. A number of these furnaces could be put in a very limited space, no solid fuel would be needed, and one air compressor would serve them all.

Earth Burial

The object of burial being speedy resolution and complete oxidation, the soil best suited for the purpose is a sandy or calcareous loam. This should be reasonably porous and light, and either naturally or artificially drained to a depth of 8 ft. Clay soil is bad as it cannot be drained properly, and allows the products of putrefaction to escape through cracks in dry weather. The same objection applies to a chalky soil. Burial is a very expensive method of disposing of the dead ; besides the initial outlay of purchasing the land there is a recurring expenditure for establishment, structural repairs, etc.

In the selection of a burial-ground the following points should be attended to :

1. The ground should not be high, as the natural drainage may pollute the water-supply at a lower level.

2. The area should be marked into plots, and provided with pathways at convenient intervals.

3. The area should be outside the town and outside the limits of future buildings. The ground should not adjoin dwellings, and trees and shrubs should be planted to absorb the carbonic acid given off during the disintegration of the bodies.

Overcrowded cemetries influence the health of the people of the locality prejudicially by (*a*) contamination of the air ; (*b*) contamination of the water by products of decomposition ; and (*c*) contamination of water-supply by specific organisms.

The number of full-sized non-masonry graves to a cottah (720 sq. ft.) of land, allowing 6 ft. by $2\frac{1}{2}$ ft. for each, and a space of 4 ft. between, would be only twelve or two hundred and forty to the bigha. If the intermediate spaces could be utilised in future without disturbing the graves, one bigha will altogether accommodate 480 corpses. In Calcutta, ordinarily, 7 ft. by 4 ft. is allotted for full-size (above ten years) non-masonry graves, 5 ft. by 3 ft. for children under ten, and 3 ft. by $2\frac{1}{2}$ ft. for infants under one year. The area should be marked out in plots and interments made in regular lines with pathways at convenient intervals. Deep burial should be avoided, and a space of at least 2 ft. should be left between the level of the subsoil water and the dead bodies. The use of metallic or strong wooden coffins, brick graves or vaults, helps to preserve the bodies for a long time, and thus interferes with their proper resolution and oxidation. Bodies should be interred in easily destructible coffins, 3 to 5 ft. below the surface of the earth, where the micro-organisms exist in abundance. Too shallow a burial should be avoided, as there is risk of the graves being dug up by jackals or other animals, and in all cases it should be protected by strong fencing. It takes about a year for the soft parts to disappear inoffensively.

The practice of burying the dead within the house is not uncommon in villages ; this should be condemned.

CHAPTER XV

PERSONAL HYGIENE

PERSONAL hygiene is not only concerned with matters touching the health of the individual, but also embraces certain personal factors conducive to good health. They are : habit, constitution, heredity, idiosyncrasy, temperament, cleanliness, clothing, exercise, etc.

Habit.—Habit plays an important part in the preservation of health. It is readily formed, grows by practice, and eventually becomes part and parcel of nature, making its eradication a matter of great difficulty. It is for this that habit is called second nature. The influence of habit in the formation of the character of individuals is known to all, but its influence on the physical and mental condition of men, particularly of children, can never be over-estimated. Indeed, it is productive of good and abortive of evil. A child brought up under a healthy hygienic environment will not tolerate the shutting up of all doors and windows or other ventilating openings. This subject may be discussed under the following heads, which are more or less influenced by habit :

(*a*) *Eating and Drinking.*—A regular habit with regard to eating and drinking is essential for the preservation of health. Food, which must always be wholesome, should be properly masticated and eaten slowly. It is a bad habit to overload the stomach. Alcohol, as a rule, should be avoided, and the very fact of craving for it is an indication of ill-health.

The following are some of the points which should be carefully attended to :—

1. Always wait for a true appetite.
2. Select the food the appetite particularly craves for at the moment.
3. Masticate well.

4. Do not swallow a mouthful unless it swallows itself.
5. Avoid reading during meals.
6. Agreeable society at meal times is advantageous.

There are certain noteworthy differences between those who are beyond sixty and those who are in middle life as regards physiology, pathology, tendencies to disease and vital resistance. This is particularly noticeable with regard to the two most important functions of animal life—eating and sleeping. Long ago Hippocrates declared in one of his aphorisms, "The old stand fasting much better than those of middle age, and those of middle age much better than the young. Children are very easily hurt by lack of food." This is the keynote of eating among the old. They need less food than in earlier years, and if they insist on eating as much as formerly they suffer from it. It is easy to understand the reason for this. They are not nearly as active as in middle life, and their heat processes within the body are much slower. Moderation in eating is of the first importance for the old.

(*b*) *Smoking.*—Smoking is not essential and should be avoided by young persons. The *hooka* or hubble-bubble is the best way of smoking tobacco as the smoke in passing through the water in the hooka is deprived of the nicotine and other injurious substances. Tobacco smoking has a soothing effect and gives to the smoker a peculiar feeling of pleasure. Excessive smoking, or smoking for the first time, produces sickness, feeling of depression and muscular weakness. Smoking sometimes affects the heart and inveterate smokers may be the victims of occasional fainting fits. The worst habit is tobacco chewing, for, even if the saliva be not swallowed, a great portion of the juice is absorbed. Nicotine often causes premature hardening of the arteries leading to degeneration of the tissues. The habit of smoking should never be indulged in by anyone below the age of twenty-one years.

According to Sir Joseph Fayrer it frequently disturbs the equilibrium of the nervous system and the action of the heart, causing giddiness, muscular tremor and palpitation ; it impairs digestion, depresses the system men-

tally and physically, and muddles the intellectual system. Cancer of the lip and tongue and chronic inflammation of the back and sides of the throat are often ascribed to it. We would counsel those who have acquired the habit and decline to relinquish it, to smoke the mildest tobacco—as seldom as possible—only after eating, and never in the morning, or not till after lunch ; or, what is still better, not till after the evening repast.

(*c*) *Sleep.*—This is the only form of complete periodical rest of both body and mind. Alternate periods of rest and activity are common to all living beings. Action involves destruction and discharge of function implies consumption of structure. Waste must be repaired and the repair must be equal to the waste. The necessity for sleep arises from the demand of certain nerve-centres which undergo waste during the hours of activity. The heart, the lungs, and the digestive tract and other organs continue to perform their respective work during sleep.

Sleep is really rest of the brain, but the spinal cord and the sympathetic system never sleep. Like other forms of rest it varies in degree and may be very slight—mere drowsiness, or very profound—complete cessation of all the functions.

The amount of sleep varies with age, occupation, and habit. Excessive sleep makes the brain less active, while its deficiency leads to prostration and general restlessness, and sometimes to sleeplessness. The amount of sleep required varies with :

(i) *Age.*—Infants sleep the greater part of the day, and the duration decreases as age advances ; adults requiring about six hours' sleep. The most important factor for the retention of health in age is sleep. Those above sixty need more sleep than they did in middle life, or at least need to spend more of their time in a reclining position. It is not absolutely necessary that they should sleep all the time, but they ought to spend at least eight hours lying down with all portions of the body on about the same level, so as to save their hearts the necessity for pumping blood against the force of gravity. The saving of the hearts by lying down is extremely favourable for

old hearts. Besides, the old should lie down for some time about the middle of their working day.

(ii) *Sickness.*—Weak, debilitated and sick persons require more sleep and repose than healthy ones.

(iii) *Occupation.*—Persons engaged in brain work require more rest and sleep than those doing physical labour.

To sleep immediately after meals is a bad practice. The old adage " after supper walk a mile " holds good at all times. The bed should be firm and elastic, and exposed to the sun daily. The head should always rest on a pillow, and the body, barring the head and face, should be covered with a sheet. The pernicious habit of a number of persons sleeping together in the same room and of covering the head and face is partly responsible for the feeble and weak health of the people of this country.

Mid-day Sleep.—" In India and other hot climates the tendency to indolence or lethargy is promoted by the heat, whether dry or moist, and more particularly by a hot, muggy, humid atmosphere, as in Calcutta, Dacca, or Bombay. To yield too much to this feeling, which only requires encouragement to degenerate into a confirmed habit, is injurious," is the opinion of Sir Joseph Fayrer. But it seems that a short nap, especially in the summer, particularly with those engaged in active work in the morning, is not only refreshing but invigorating.

Constitution.—Individual differences in constitution exist in different persons. Some are strong and robust, while others are feeble and weak. Moreover, resistance to disease varies with the constitution. A man with a strong or robust constitution does not fall an easy victim to disease.

The constitution of a person is partly acquired and partly inherited, and a strong constitution may be enfeebled under unhygienic conditions, while a delicate one may improve under hygienic ones.

Heredity.—This has a great influence on health. Certain diseases are generally transmitted to the offspring,

e.g. gout, insanity, syphilis, etc. The appearance in one individual of traits not possessed by his parents, but known to have belonged to his more remote ancestors, is termed *Atavism*. Mental peculiarity and similarity of features are often inherited.

Idiosyncrasy.—By this is meant a peculiar susceptibility of some persons to be influenced by certain morbid agencies or medicinal preparations, *e.g.*, the appearance of nettle-rash with some as a result of taking shell-fish.

Cleanliness

The most important condition of healthful growth and development is cleanliness. Dirt is not only harmful but antagonistic to our very existence. Cleanliness with regard to the food we eat, the air we breathe, and the water we drink, is imperative for good health. In India cleansing of the skin is of immense value inasmuch as the amount of perspiration and excretion of solids is considerable. In fact, much of the work of the kidneys and lungs is performed by the skin in hot countries. The sweat glands which open on the surface of the skin help to relieve the body of a portion of the effete material. If they are blocked up by dirt not only is their action interfered with and extra work thrown on the lungs and kidneys, but they form favourable sites for the production or propagation of diseases of the skin. It is therefore of primary importance to see that the orifices of these glands are kept clean. The sebaceous glands secrete an oily substance which acts as a natural pomade. Certain parts of the body like the armpits give out an unpleasant odour from their secretions and so require regular cleaning. Cleansing of the skin is best effected by soap and water.

Soap.—When an oil or fatty acid, *e.g.*, palmitic, stearic, or oleic, is acted upon by an alkali (sodium or potassium salt) soap is produced, with glycerin as a by-product. Potash soaps are known as *soft soaps*, and they are highly deliquescent ; while soda soaps are called *hard soaps*. Excess of soda irritates the skin.

It should be observed that individually the substances employed in the manufacture of ordinary soap are ill-suited for the purpose of cleansing the skin. Caustic soda is corrosive and dissolves the cuticle, while the oils and fats do not mix with water. But by their chemical action a new compound is formed which is almost harmless to most skins and their destructive qualities are entirely lost.

In India inunction of the body with some bland oil before bathing is a very popular custom. The oils usually used are either the expressed oil of mustard or cocoanut oil either by itself or perfumed. The utility of such a practice is evident. It not only keeps the body cool, renders the skin soft and supple, and helps the introduction of a certain amount of fat, but entangles the dirt of the body and facilitates its removal during bathing, especially when soap is used. Moreover, it facilitates shampooing or massaging of the body which may with advantage be done just before a bath. By kneading and rubbing the circulation is quickened and the muscles exercised, giving an exhilarating and refreshing feeling.

Baths.—Baths are necessary not only for cleanliness but also for their beneficent action on the skin and internal organs. According to Professor Braun baths are less needed by those who perform muscular work, because the functions of the skin and perspiration are sufficient in themselves to perform the task of cleansing.

Baths may be classified according to the temperature of the water, as follows :—

Cold	..	.. 33° to 65° F.
Cool	..	.. 65° to 75° F.
Temperate		.. 75° to 85° F.
Tepid	..	.. 85° to 92° F.
Warm	..	.. 92° to 98° F.
Hot	..	.. 98° to 112° F.

Warm Bath.—It has a stimulating action on the skin and reflexly excites the heart and circulation. As a cleansing agent, a warm bath, when used with soap, is the best. It increases the danger of chills if there is subsequent exposure, but this sensibility to cold may

be obviated by a rapid cold sponging and then drying the body quickly.

Cold Bath.—The first effect produced by a cold bath is one of shock followed by contraction of the superficial blood vessels, but the vessels dilate very soon, giving the person a feeling of warmth and pleasure. Cold baths should be taken as quickly as possible and the body covered immediately afterwards. People living close to the sea, lake or river, usually take "plunge baths"; these are beneficial to the young and the healthy, and for those possessing the power of ready reaction.

Baths should not be taken during a fast, or just after a full meal, or during exhaustion. The best time for taking a bath is the morning; if taken at night it should, as a rule, be a warm one.

The skin is a delicate organ, and when covered by clothing becomes highly sensitive to thermic influences. Hence the people of India, who are accustomed to keep their body bare, rarely suffer from the effects of cold to the same extent as Europeans. The temperature of the bath should first of all be such as can be borne without discomfort; then it should gradually be reduced, and in this way only sensitive skins may be brought to bear perfectly cold water. But the temperature of water should always depend upon what is called the power of reaction, that is readjustment of the free cutaneous circulation without giving rise to any internal congestion. Sometimes, instead of that pleasant feeling of exhilaration, vigour, and greater capacity for mental and physical work, the reaction is delayed and the vessels remain constricted, as evidenced by a sensation of fullness of the head and abdomen, faintness, tight feeling over the chest, and depression. Then the cold bath is unsuited and must be discontinued. Under such circumstances the water should have the chill taken off, be tepid, or even warm.

Personal Cleanliness.—This involves attention to the skin, mouth, nails, hairs, and other parts of the body. The mouth should be kept perfectly clean and teeth regularly attended to. Tomes gives the following directions for the proper management of teeth: "The teeth

should be thoroughly cleaned at least twice a day with a brush of only moderate hardness ; and if the teeth are inclined to decay between, or there are fillings between them, floss silk should be carefully passed through, so as to thoroughly clean the surface. Any place where the food habitually lodges, and whence it is not promptly removed, is quite sure to decay sooner or later ; and on the other hand teeth rarely decay on a fully exposed surface. It will be seen, therefore, that most scrupulous cleanliness is the best of all preservatives for the teeth, and that the more delicate they are, the greater the need of frequent and thorough brushing--a thing which can hardly be overdone."

The *tongue* should be cleansed by a tongue-cleanser every morning. The *nails* require to be kept clean and cut short, otherwise dirt will lodge under them and may carry infection. The *hair* requires to be daily brushed and combed. The chief necessity for the hair is not so much daily ablution, for this may be carried to excess, but cleanliness. Proper and thorough cleansing is required both for men and women. This is best done with soap and hot water, or yolk of egg, washing soda, or better still by the use of *soap nut* solution (water prepared by steeping soap nut for a few hours). One should always practice to shave himself and must avoid a barber's razor.

Clothing

The principal objects of clothing are :

1. To afford protection to the body against heat and cold, and external injuries ;

2. To assist in the maintenance of bodily heat ;

3. For personal decoration and ornamentation (of lesser importance).

A perfect dress, therefore, should fulfil the above requirements. The materials for the dress should be such as to exercise no harmful effect on the skin directly in contact with it. Children and old people are very susceptible to changes of temperature, and are more prone

to suffer from congestion or inflammation of the internal organs : particular care should therefore be taken in the matter of their dress.

The following points should be considered in the selection of materials for dress :

1. The dress should in no way interfere with the healthy action of the skin ; for this purpose porous materials which absorb moisture readily should be preferred. The use of flannel or gauze banians next to the skin lessens the liability to attacks of chill. Certain materials absorb heat and are non-conductors others again reflect more. By a careful selection we can so prepare our clothing as to suit all climates and seasons. In cold weather the non-conducting properties will not permit the escape of the animal heat excepting in a very tardy manner, and during hot weather they will be slow to conduct heat to the skin from without. The greatest amount of heat will be derived from wool and the least from linen.

It is of little consequence whether the dress worn next to the skin is red, blue, or white, as long as it will maintain the proper heat of the body. But it makes a great deal of difference with regard to heat that acts upon the body from without. The same material will absorb different amounts of heat when dyed with different colours.

2. All tight clothes should be avoided, as they interfere with circulation, respiration, digestion, and the action of muscles. Other things being equal, a loose dress is warmer than a tight-fitting one. In loose-fitting garments there is a stratum of air between the skin and the articles of dress which has an important influence on the bodily heat. Air is a bad conductor of heat, and here it acts in the same way as a separate garment. Garters of every description should be condemned—they compress the superficial veins and give rise to a feeling of heaviness and may lead to the development of varicose veins.

3. The warmth of the clothing should be distributed throughout the body uniformly.

4. All clothes should be light and warm, and their weight should be uniformly distributed.

5. They should not have any irritating or poisonous action on the skin. Certain clothes are coloured with poisonous dyes and the poison generally used is arsenic. Some materials again have an irritating or stimulating effect on the skin, depending on its sensitiveness and the susceptibility of the individual. Some persons cannot wear woolen or flannel underwear; but the body accommodates itself to a variety of circumstances, and a sensitive skin becomes very soon accustomed to the stimulation, and ceases to respond to a rough garment.

Materials for Clothing

The materials used for clothing are derived partly from the animal and partly from the vegetable kingdom. From the former is derived wool, silk, fur, leather, etc.; and from the latter—cotton, hemp, flax, etc. Of these, wool, silk, cotton, and flax are the most important and commonly used. These can be distinguished by their physical and microscopical characters and by chemical reactions.

Wool.—It is the natural covering of many animals. Its value depends upon the presence of oil and fat, and in the form of cloth it imprisons a certain amount of air between its interstices, thus preventing heat passing through it. It therefore forms a valuable garment in India during winter. Its hygroscopic property is of much value in the hygiene of clothing.

During profuse perspiration, wool absorbs water and diffuses it through its meshes. This water undergoes evaporation, but the cooling effect which might have been harmful to the body is directed towards the garments and is removed from the skin. As underclothing, therefore, woolen garments have overwhelming advantages, and of all materials they are best suited for varying circumstances of life. Wool is, as a rule, heavy and often irritates the skin when worn next to it. For the old, the delicate, the scrofulous and the rheumatic, woolen underdress is especially beneficial. Woolen materials are less cleanly than cotton or linen ones, because they soil less readily and show less the outward signs of dirt, and shrink

on washing. Woolen garments should be smooth and soft and the texture should be close.

Silk.—Silk is a fibrous substance spun by the silkworm. The fibres are about $\frac{1}{2000}$th in. wide, having no scales or surface markings. It is a bad conductor of heat, less absorbent than wool, but better than cotton. It is soft, smooth, and gives a soothing feeling to the skin, and is therefore the best material for underwear.

Satin is a special preparation of silk with a smooth polished surface.

Leather.—Leather is chiefly used for boots, but being very close and firm in its texture it forms an exceedingly warm covering, as it allows no air to penetrate through it. The skins of the ox, sheep, horse, and goat are generally used. It is impervious to moisture and therefore keeps the skin not only hot but clammy. The chief objection to its use is that it gets stiff when dried after washing.

Feathers.—Their use is more for ornamental purposes than for covering the body. Pillows and quilts are often stuffed with them.

Cotton is the downy hair enclosing the seeds of the different species of the plant *gossypium*. The fibres are flat and ribbon-like, varying from $\frac{1}{1000}$th to $\frac{1}{4000}$th in. in thickness. Cotton has the advantage of being hard, durable, and cheap. It absorbs odours readily, is warmer than linen, and does not shrink in washing. Its fibres are hard and it is inferior to wool as warm clothing. It is mixed up with woolen materials to increase durability and to prevent shrinking. It is a good conductor of heat and conveys to the skin the heat from without and allows the body to be rapidly influenced by the conditions of the external atmosphere. But cotton materials, unlike woolen fibres, have a very feeble hygroscopic property.

Cellular cloth is made from cotton, and the fibres are so woven as to leave cellular air interspaces in the texture. The enclosed air being a bad conductor helps to retain the heat of the body.

Linen.—This is made from flax which is obtained from the fibres of the flax plant. It is a good conductor of heat like cotton and bad absorbent of moisture. It has no

advantage over cotton as an article of clothing; as it can be woven into finer materials it takes a higher finish.

Cummerbund.—A chill in hot climates often leads to serious intestinal troubles in Europeans, and a flannel binder or a cholera belt should as a rule be worn, especially at night. It is rather difficult to keep a flannel binder in position, and a cholera belt is best for the purpose. A bed sheet or a blanket is often tossed off, and the abdomen is chilled by the draught of the punkah or fan which is often kept going the whole night.

Socks or Stockings should always be worn with boots or shoes, although the practice with most people in India is to do away with them. They should not be very tight or pointed at the extremity; when too short they cramp the toes, and when too long, as often happens with children with the object of "allowance for growth," a mass of superfluous material remains at the extremity of the boot. They should be washed or exposed to the sun daily as they smell badly from perspiration.

Boots and Shoes.—They should conform to the normal outline of the sole. The measurement of the foot should be taken when resting on the ground and always over a thick pair of socks. It is better to have a size bigger than is actually necessary. The sole should be flexible; a rigid sole destroys the main action of the foot in the act of walking. The leather should be soft and pliable, consistent with strength. Boots should be worn in preference to shoes to protect the ankles from the bites of mosquitoes.

Clothing for Children.—The general principles already laid down apply equally to children; but certain conditions render the dress of this period of life a matter for special consideration:

(*a*) Infants require to be properly protected by clothing. Their clothing should be soft, light, warm, and loose. The notion that by clothing children lightly and by exposing them at an early period to cold, they become accustomed to fluctuations of temperature and are "hardened" is a delusion, and is accountable for no small contribution to infant mortality.

(*b*) The dress should be loose and free from constrictions.

(*c*) Under no circumstances should the garments be tied tightly to the waist. They should be light and in number consistent with the due protection of the body.

(*d*) The body should be perfectly and evenly covered with clothing.

Exercise

The necessity of exercise for the preservation of health cannot be over-estimated, yet perhaps few realise the importance of the changes it involves. Exercise is essential for the different organs of the body to work easily and effectively. It is also necessary to excite the demand for oxygen required for utilization of food and to promote the repair and formation of tissues. It is extremely important for old age not to lapse into habits of inactivity ; there is the temptation of a man well on in years to give up walking to a great extent, to ride in carriages and to sit in the house a great deal. What has been learnt about the heart in recent years shows that unless it gets a certain definite amount of exercise it does not do its work as well as it otherwise would. According to Parkes a man takes about eight and a half ounces more of oxygen on a " work day " than on a " rest day." Exercise should therefore be taken in the open air to allow a free supply of oxygen for the demands of nature. Physiological exercises are useful in the following ways* :—

1. To develop the weakly and the overgrown.
2. To restore those convalescent, whether generally as from illness, or locally as from injury.
3. To correct during youth various deformities.
4. To relieve certain conditions—as debility and obesity.
5. To relieve local conditions after certain lung diseases.

* Albutt's *System of Medicine*, vol. i.

6. To preserve the healthy tone of the body of those who by necessity or habit, virtue or vice, cannot do so in their ordinary life.

7. To enable the body to counteract the baneful effects of educational efforts focussed on the mind.

8. As an educational measure for the mentally deficient.

Effects of Exercise on Different Organs

1. *Respiratory System.*—During exercise the action of the lungs should be thoroughly free, and there should not be any impediment to the full play of the chest by dress or any other means. The pulmonary circulation is quickened, the amount of air inspired and of carbon expired is greatly increased. It is obvious that increased output demands increased supply of food and fresh air. Alcohol diminishes the excretion of CO_2 and should therefore be avoided during exercise.

2. *Circulatory System.*—Active exercise increases the force and frequency of the heart with acceleration of circulation, but this is followed by a period of depression.

3. *Muscular System.*—The nutrition of muscles is improved which contributes to their growth and energy. It seems probable that muscles lose water during exercise.

4. *Cutaneous System.*—Exercise promotes the action of the skin. It leads to engorgement of the vessels with increased perspiration which in evaporating from the surface of the skin reduces and regulates the temperature. But during active exercise there is less danger of chill, as the loss is replaced by a rapid supply. The risk, however, increases after exercise and therefore the surface of the body which was exposed during exercise requires to be covered and protected from undue loss of heat.

5. *Urinary System.*—The excretion of urea is unaffected but uric acid is increased. On account of the increased action of the skin the watery portion and the chlorides of urine are diminished.

6. *Nervous System.*—Men engaged in brain work must recreate themselves with active exercise which leads to perfect performance of mental work.

7. *Alimentary System.*—The amount of fæces passed is lessened, and by removing constipation it induces a regular action of the bowels.

Effects of Excessive Exercise.—Excessive exercise causes either nervous or muscular fatigue. Mental fatigue is an important factor particularly with the young, the weak, and the invalid. For those with a sedentary habit it is best to have recourse to graduated exercise which requires some effort of the mind and will in its execution. Riding, rowing, swimming, etc., may with advantage be undertaken buy them. For neurasthenic people an opposite course demanding less nervous effort is necessary.

Diseases of the heart—such as palpitation, hypertrophy, etc., or muscular wasting, may be caused by excessive exercise. After exercise the body should be washed or sponged, and since exercise increases elimination of water, salts, carbon, and nitrogen from the body it is essential that these should be replaced. Along with exercise rest is equally necessary, and it is said that excessive exercise lowers the opsonic index even in perfectly healthy persons.

Amount of Exercise Necessary.—It is rather difficult to determine even in the case of an average man the amount of exercise that should be taken to maintain health. By "unit of work" is generally meant to be the quantity of work which is done in lifting one pound through a height of one foot ; this quantity of work is called one "foot pound." According to Parkes an ordinary day's physical work for a healthy man is equivalent to raising 250 to 350 tons one foot high ; this is a moderate amount, 400 tons being a heavy day's work. The amount of muscular exercise involved in this may be easily known by remembering that a walk of 20 miles on a level road is equivalent to about 353⅔ tons lifted one foot ; and that a walk of ten miles while carrying 60 lbs. is equivalent to 247½ tons lifted one foot (Haughton).

It has been calculated that at an ordinary rate of three miles per hour, a man, walking along level ground, does work equivalent to raising his own weight, vertically, through $\frac{1}{20}$ th the distance travelled ; or raises $\frac{1}{20}$ th of his weight through the whole distance travelled.

The fraction $\frac{1}{20\cdot59}$, or approximately $\frac{1}{20}$, is spoken of as the *co-efficient of traction*, and varies with the rate of walking. At three miles per hour, on a level ground, it is equivalent to $\frac{1}{20.59}$, at four miles $=\frac{1}{16.75}$, and at five miles $=\frac{1}{14.10}$.

To estimate the amount of work done by a man in walking the following formula is generally used :

Let W = Weight of the man in pounds.
W′ = Weight he carries.
D × Distance walked in feet.
C = Co-efficient of traction.

Then $\frac{(W+W')\times D}{2240}\times C=$ foot tons (2.240 is the number of pounds in a ton).

The following rules should be observed with regard to exercise.

1. Exercise should be taken in the open air, repeated daily about the same hour, and never taken just after or before a meal.
2. Every part of the body should share in the exercise.
3. Exercise should be regular and systematic.
4. Chills should be avoided after exercise.
5. The amount of exercise should be regulated according to the age and physical development of the person.

CHAPTER XVI

CLIMATE AND METEOROLOGY

THE climate of a place or region is the sum total of all the meteorological conditions in their relation to animal and vegetable life. It was formerly supposed that the climate of a place was dependent upon its distance from the equator. Although this is an important factor in the determination of climate there are other conditions which also materially affect the climate of a particular place. They are :

1. The altitude.
2. Distance from the sea.
3. Prevailing wind.
4. Nature of the soil.
5. Proximity of mountains and hills.
6. Rainfall.

Besides the above the following conditions affect the climate of a given locality :

(*a*) Cultivation of the soil.
(*b*) Presence of marshes, tanks, etc.
(*c*) Presence or absence of forests.

There can be no doubt that climatic conditions have an important effect on health, as is evidenced by the geographical distribution and seasonal prevalence of disease. Further, it is a known fact that climate is an important factor in determining the characteristics of the races of mankind. Amongst these may be mentioned variations in the pigmentation of the skin. There are other variations chiefly due to environment developed in the course of many centuries. In the north-west of India the dry climate and the constant struggles with man and nature have combined to produce a race brave and hardy with good physical development.

The tropical zone embraces nearly half of the earth's surface, and is bounded by the tropics of Cancer and Capricorn—lat. 22° 5′ north and south—by the mean annual isotherms of 68° and by the polar margins of the trade winds.

Acclimatisation

Acclimatisation means adaptation to a particular climate. There are two views regarding acclimatisation. One school holds that acclimatisation is impossible and that Europeans can never be acclimatised in a tropical climate. According to them deterioration caused by climatological factors and endemic diseases will either kill them or render their existence impossible; while Livingstone, the late Bishop Hannington, and Dr. Sambon are of opinion that *rapid* acclimatisation is possible for Europeans. But it appears that although acclimatisation of Europeans is possible in course of time, any attempt at rapid acclimatisation has an influence injurious to health. If carefully selected individuals are allowed to colonise in well-chosen tropical areas with facilities for occasional changes to the hills, there is no reason why acclimatisation should prove an impossibility. But this must be very slow, and persons with a tendency to any chronic disease like gout or rheumatism, diabetes or albuminuria, or those suffering either form acquired or hereditary syphilis, are not so well suited for the purpose.

Acclimatisation is effected by a slow process of change taking place either in the individual or in the race by constitutional modifications brought on in different generations. The body adapts itself to the circumstances and conditions in which it is placed. All Europeans however cannot be acclimatised in a given area equally. Besides the climatology of their original residence, the habits, customs, and other peculiarities have to be taken into account with regard to their adaptability for emigration. But selected persons from almost every European nation may thrive all over the world.

Rapid acclimatisation with regard to Europeans is only possible in the temperate zone. It has been suggested

that acclimatisation of Europeans in India is impossible unless they intermarry. But this is not true acclimatisation; for, the race is altered and transformed into a mixed race, which ultimately has very little in common with the original stock.

Race itself does not always provide us with a definite proof of capability of acclimatisation, for in India the Hindu population, notwithstanding its Aryan origin, has thriven under unfavourable circumstances, and even in malarial districts, thus presenting a striking contrast to the English (also an Aryan race), whose intolerance of the Indian climate is obvious.*

Climate in Relation to Health

Various meteorological conditions have an important influence on climate and health. Of these temperature, humidity, and atmospheric presssure demand special consideration.

Temperature.—The temperature of the air influences the climate, and forms the basis for its classification. The chief source of heat in the atmosphere is the sun, but distinction must be made between the "sun heat" or "radiant heat" and the "air heat" or "shade temperature." Radiant heat is the heat directly radiated from the sun which warms the human body and other solid and liquid objects on which it falls; but it has very little power in warming the air through which it passes. Shade temperature is the result of the emanation of heat which the sun's rays have imparted to the surface of the earth. In sea coast regions the temperature is influenced by the ocean and the difference between the hot and cold seasons is less marked, and the climate is known as *equable*. In mountainous regions the altitude diminishes the mean annual range of temperature. The climate of inland places is rather variable, being extremely cold in winter and very hot in summer. In addition to these seasonal variations, fluctuations of temperature occur almost

* "Climate and Acclimatisation," Green's *Encyclopædia of Medicine* vol. ii.

daily. This is less marked in places with a constant temperature and in sea coast climates, and more marked in inland and temperate climates.

Influence of Temperature on Health.—The most vigorous races are produced in places where the temperature is changeable and the difference between hot and cold seasons is great, while weak and languid races of men are to be seen in places having an equable temperature.

The high temperature of the tropics causes certain important changes in the European constitution. There is an increased peripheral circulation with a great activity of the functions of the skin causing profuse perspiration, which in its turn keeps the body temperature normal. This adjustment of the system to counteract the external heat is not often sufficient for a newcomer and the body temperature remains slightly higher than normal. The number of respirations is diminished, and from the fact that hot and rarefied air contains comparatively less oxygen, the intake of oxygen with the inspiration and the output of CO_2 with the expiration is also lessened. On the whole the general effect is that of diminished vital activity : the heart is weakened with slowing of the pulse, digestion is impaired, appetite lessened and nutrition interfered with, as evidenced by loss of weight and diminished bodily activity. The effect of heat on the system may be either direct or indirect. Directly it may cause diseases like sunstroke or fever, or may interfere with or suspend some of the most important and natural functions of the body. Indirectly it may produce heat syncope, deterioration of the blood and congestive disorders affecting the liver and bowels.

Effects of Cold on Health.—The effects of cold are opposite to that of heat. Whatever may be the temperature or thermometric readings, cold and its ill-effects are not uncommon in India. The cold season in Calcutta is very pleasant and invigorating to those enjoying sound health, but to many, at least at its beginning, it gives rise to chill and internal congestion. Of all the vicissitudes to which the climate of India is liable, none interfere with health so seriously as the rapid transitions of its

temperature do. The common ill-effects of the sudden transition of temperature are acute hepatitis, colic, acute diarrhœa, or dysentery. When a person in the hot season leaves the plains for the hills, where the ascent is sudden, a rise of a few hundred feet accelerates the heart's action, checks perspiration, and causes profuse diuresis, or he may get a sharp attack of diarrhœa.

Effects of Humidity on Health.—A certain amount of moisture is always present in the atmosphere, and climates have been classified into *moist* and *dry* according to the degree of humidity. The degree of dryness or moisture of the air is expressed in terms of relative and not of absolute humidity. The amount of moisture in the air increases with the rise of temperature. At freezing-point air contains two grains of watery vapour, whereas it contains eight grains at 70° F. It follows therefore that air which is damp at a low temperature or saturated with moisture becomes dry when the temperature is raised, even though the absolute quantity of moisture remains unaltered.

Excessive humidity retards evaporation from the lungs and skin inasmuch as the atmosphere, being very liberally charged with moisture, exerts little or no drying effect. The evaporation of moisture by which the cooling of a body is effected causes a certain amount of heat to become very oppressive although not so trying as when combined with extreme cold. Moist climates are less healthy than dry ones, as moist air favours the growth and development of micro-organisms. Putrefactive changes take place more readily in moisture than in dryness.

Effects of Atmospheric Pressure on Health.—Atmospheric pressure is an important factor of climate. It varies according to altitude and movement of the air. Its influence on health may be considered under the two following heads: (1) the effects of diminished pressure, and (2) the effects of increased pressure.

(1) *Effects of Diminished Pressure.*—760 mm. (30 in.) of mercury or a weight of 15 lbs. on every square inch is the pressure of air at the sea-level. At high altitudes the pressure diminishes on account of the rarefaction of the

air; roughly, an ascent of 1800 ft. takes off 1 lb. For an ascent of 300 ft. the temperature is reduced by 1° F. The weight of oxygen in a cubic foot of air is also diminished in proportion to the diminution of pressure.

The physiological effects are directly referable to want of oxygen; they are characterized by cyanosis, nausea, headache, intestinal disturbances, and fainting. Bleeding from the nose, ringing in ears and palpitation are not infrequent symptoms. The number of corpuscles are said to increase, but in balloon ascents this is ascribed not to any fresh formation of blood, but to excessive secretion of lymph, which leads to concentration of the blood. This disturbance known as "Aviator's sickness" is also due to low barometric pressure. The pressure of the oxygen in the arterial blood in high altitudes may be higher than in the alveolar air. Active secretion of oxygen occurs in the lungs and there is a tendency to slowness of the heart in aviators after a sudden descent.

(2) *Effects of Increased Pressure*— Increased pressure of air produces effects of an opposite nature, but the system soon accommodates itself to this altered condition. The effects are best observed in persons working in diving-bells, compressed air chambers (caissons), etc., and the symptoms produced are generally known as "caisson disease." In caissons the pressure is rarely 30 to 35 pounds, and the divers go down to 20 fathoms with a pressure of 53 pounds. Two views are held: (1) During compression the blood passing through the lungs becomes saturated with nitrogen which is carried to the tissues until the whole body is saturated; during decompression the process is reversed. The nitrogen is liberated causing emboli, which block up the spinal vessels. (2) The blood is driven from the surface, causing distention of the vessels with paralysis of the walls; when the pressure diminishes they are unable to accommodate themselves to the changed condition, and stasis with congestion and hæmorrhages follow. As a rule the workers do not suffer whilst they are in the caisson, but grave symptoms may take place after they have returned to the outside air. The common symptoms are paralysis,

vertigo, abdominal pain, vomiting, etc. In extreme instances the attacks resemble apoplexy; the patient rapidly becomes comatose and death occurs in a few hours.

One or more locks should be provided in which the pressure can be gradually reduced until approximately that of the atmosphere is reached. Divers should be instructed to come slowly to the surface. When the pressure exceeds three atmospheres the longest working period should not be more than one hour, and several hours should be permitted between the descents. A chamber should be provided where a man showing symptoms of the disease may be once more subjected to a pressure greater than that of the atmosphere. Haldane's "Stage Method" is now widely adopted with most beneficial results.

Classification of Climates

For purposes of classification three great climatic conditions were originally described:—

1. The hot or warn climate with a mean annual temperature of 80° F.
2. The temperate climate with 60° F., and
3. The cold climate with 40° F.

A more scientific division is made by using iso-thermal lines, as very often the regions occupying the same latitude give different annual temperatures.

For practical purposes climates are divided into: (1) cold, (2) temperate, (3) warm, (4) mountain, and (5) marine and oceanic.

(1) *Cold Climates.*—These belong to regions lying between the Poles and 50° of latitude. Here the winter is severe and prolonged, and the summer is very short The mean annual temperature varies from 50°F. to 40°F., or may be even below the freezing-point. Rain is comparatively absent, but there is abundance of snow. Although severe cold has a tiring effect on the lungs and kidneys yet according to some observers the death-rate in these regions is the lowest in the world. Severe cold makes the inhabitants vigorous and muscular, and

improves the power of digestion. But owing to the deficient growth of vegetables and the unhygienic condition of the people living in these regions they are very prone to suffer from scurvy.

(2) *Temperate Climates.*—The geographical limit is from 35° to 50° of latitude, and the mean annual temperature varies from 50° to 60° F. These are the healthiest climates upon the earth, and are inhabited by the most civilised and vigorous races of the world. Four well-defined seasons exist in these latitudes, autumn and winter being usually most rainy.

(3) *Warm Climates.*—These include regions lying between the Equator and 35° of latitude on either side of it, and contain within their limits Southern Asia (including India and China), Polynesia, Africa with its islands, North America south of California, and South America north of Uraguay, and the West Indies. They are subdivided into *equatorial*, *tropical*, and *sub-tropical* climates. In the equatorial the maximum temperature is 118° F., the minimum 54° F., and the mean annual varies from 80° to 84° F. High temperature, heavy rainfall with well-defined dry and wet seasons are the characteristics of these regions. The heat is modified by rainfall which is rarely less than 40 in. annually, and the difference between the diurnal and nocturnal temperatures is slight. The diseases commonly attributed to warm climates are : insolation or sun stroke, cholera, malaria, yellow fever, dengue, liver abscess, small-pox, dysentery, diarrhœa, kala-azar, etc.

(4) *Mountain Climates.*—The characteristics of mountain climates are extreme heat and cold, greater purity and rarefaction of air, and diminished atmospheric pressure due to high altitude. Mountain climates are best suited to persons, with a tendency to tuberculosis.

(5) *Marine and Oceanic Climates.*—The peculiar features of these climates are greater equability of temperature, and increased moisture and rainfall, as evidenced by the climates of small islands and places on the sea-coast. The climates of Great Britain, Ceylon, and the coasts of India may be mentioned as examples. The

good effects of sea air are ascribed to its great purity and the presence of ozone which has a general tonic effect on the constitution. The variations of temperature between summer and winter, and between day and night, are less marked.

Effects of Vegetation and Sheets of Water on Climate

Vegetation in moderation improves the climate by keeping the air cool and equable, and counteracts the effects of radiation from the earth. Trees exert an attractive influence on the water-charged clouds and so rainfall and relative humidity are correspondingly increased.

The deprivation or absence of vegetation, as in deserts or dry lands, leads to great variations of temperature. They are very hot during the day, and owing to the dryness of the air radiation is very rapid at night when the temperature falls down considerably.

The effect of ocean, lake, or any large sheet of water is very great in influencing the climate of a place. The specific heat of water is four times greater than that of land, with the result that it takes a longer time for heating as well as for cooling. It follows, therefore, that the temperature of the atmosphere close to large sheets of water would remain uniform. Sea water freezes at a temperature of about 28° F. and fresh water at 32° F., consequently the sea remains open when the lake freezes ; hence the sea exerts a greater influence in moderating winter cold and summer heat.

METEOROLOGY

Meteorology is the science concerned with the phenomena occurring in the atmosphere ; while *weather* is the general condition of the air at any stated period or time, particularly of that portion of the air lying next to the earth's surface. In all meteorological observations the results obtained by different observers at different stations are recorded by instruments which must be similar in

form and exposed in the same way. It is necessary also that all mistakes peculiar to these observations must not be lost sight of. All observations must be systematically and accurately made and their results interpreted.

The meteorology of India is of special interest, presenting as it does a greater variety of meteorological conditions, actions, and features than any other place of similar size in the world. This is ascribed to (1) its variety and contrasts, (2) presence of a combination of tropical and temperate conditions, and (3) its being an area of pronounced monsoon conditions. The principal climatic phenomena requiring systematic record are :

I. The temperature of the atmosphere.
II. Atmospheric pressure.
III. Movement of wind.
IV. Humidity.
V. Presence of ozone.
VI. Sunshine or solar radiation.
VII. Atmospheric electricity.
VIII. Rainfall.
IX. Presence or absence of cloud, fog, mists, and storms.

1. Temperature

Next to rainfall temperature is the most important feature of meteorological observations. This is recorded by thermometers which are exposed in open sheds to allow a free circulation of air, and protected from the direct rays of the sun by a thick roof or thatch. In cold weather and during the hottest part of the day the temperature of the ground surface is about 10° to 20° higher than that of the air at 4 ft. high, and this goes on increasing up to 40° or 50°. But this difference becomes less during the rains. The mean daily temperature, or simply temperature, is that obtained by adding twenty-four hourly observations and dividing by twenty-four. The temperature of a month is the mean of those of thirty days, and the temperature of a year is the mean of those of twelve months.

The temperature of the air varies at different parts of the day. It is increased by the absorption of solar radiation during the day. The variation of temperature with a maximum and minimum, dividing the day into periods of eight and sixteen hours, is the *diurnal variation*, and the difference is the *diurnal range*. There is again what is called the *annual variation* of temperature ; this is the regular increase in the temperature during one-half of the year succeeded by a decrease during the other half.

The temperature of the air of a particular place varies, and the principal causes which modify the temperature are : (1) latitude of the place, (2) height, (3) direction of wind, and (4) proximity of the sea. In the north-western parts of India and the northern parts of the Bombay Presidency the daily range of the thermometer is very great during the months of October and November when the difference between the maximum and minimum temperature fluctuates between 30° and 35° F., while in the United Provinces it averages between 28° and 32° F. The amount of diurnal periodic change is less on sea than on land, and least on the sea-coast of the islands in the tropics. The amplitude of yearly fluctuation is less on sea than on land and is least in tropical countries.

The lines which connect places which have the same mean temperature are called *isothermal lines* ; these mean temperatures may remain the same either for the year or for several months.

Thermometers.—Thermometers are instruments for measuring temperature. Liquids are by far the best suited for their construction, and mercury and alcohol are the fluids generally preferred. Mercury is used as it boils at a very high temperature, and because of its regular expansion ; alcohol, on the other hand, has the advantage of not solidifying even at the lowest known temperature. Of these, mercurial thermometers are more widely used.

Six's Thermometer.—It is a combination of maximum and minimum thermometers and gives a double reading. It consists of a **U**-shaped glass tube with a bulb at each end, the middle portion of which contains mercury. Both

the tubes above the mercury and one bulb contain alcohol, and part of the other bulb contains alcohol vapour and air. In each stem there is an iron index which may be moved by a magnet. With the rise of the temperature the alcohol expands and pushes the mercury and with it the index well up the other stem. With the fall of the temperature the alcohol contracts and the mercury falls and with it pushes up the index in the other column. In this way the highest and the lowest temperatures are recorded by the indices in the right and left limb respectively.

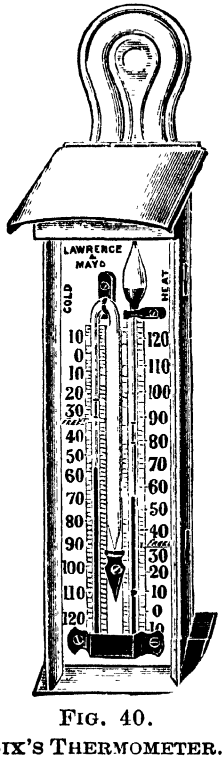


FIG. 40.
SIX'S THERMOMETER.

Maximum and Minimum Thermometers.—In meteorological observations the highest and the lowest temperatures in the twenty-four hours are often necessary, for which purpose these thermometers are used. They consist of a wooden board upon which two thermometers are fixed, the bulbs of which are bent at right angles and the stems are placed horizontally. The upper one contains mercury and indicates the maximum temperature, and the lower one is an alcohol thermometer. The mercurial one has an index of a short rod of glass or wood which moves freely in the tube. When the thermometer is placed horizontally the index is pushed with the rise of temperature and consequent expansion of mercury, but remains at the same place even after the mercury has contracted; thus registering the highest temperature of the day. In the alcohol one, the index is a dumb-bell shaped glass which is drawn by capillary attraction until it has reached the greatest contraction. But when the alcohol expands with the rise of temperature it passes between the sides of the tube and the

index, and therefore does not displace it. It thus records the lowest temperature that has been reached.

Vacuum or Solar Radiation Thermometer.—This is a mercurial maximum self-registering instrument having a bulb coated with lamp black to absorb the sun's rays. The bulb is placed in a vacuum glass case in order to prevent the coating from being washed off by rain. The glass case also protects the bulb from loss of heat which would otherwise take place. The instrument is placed horizontally 4 ft. above the ground, away from walls and trees, and exposed to the rays of the sun direct. The difference between the maximum in the sun and in the shade is the amount of solar radiation, or of the power of the rays of the sun.

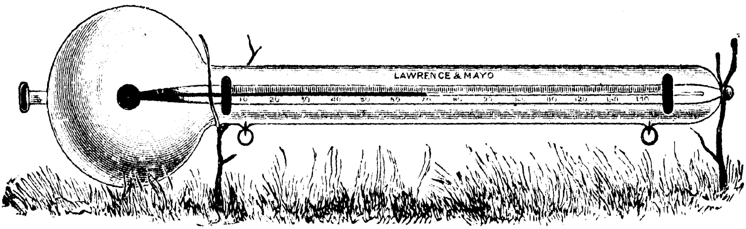


FIG. 41.—VACUUM OR SOLAR RADIATION THERMOMETER.

A terrestrial thermometer is a minimum shade thermometer placed close to the ground with the bulb resting on the grass about 4 in. above the ground. If a grass plot cannot be had the thermometer should rest on a large black board placed upon the surface of the ground, or it should be laid on snow if the ground is so covered. The difference between this minimum temperature and the air minimum in the shade is the amount of terrestrial radiation.

II. ATMOSPHERIC PRESSURE

The atmospheric pressure is determined by means of a *barometer.* It may be either a mercurial, glycerine, water, or aneroid barometer ; mercury being the heaviest

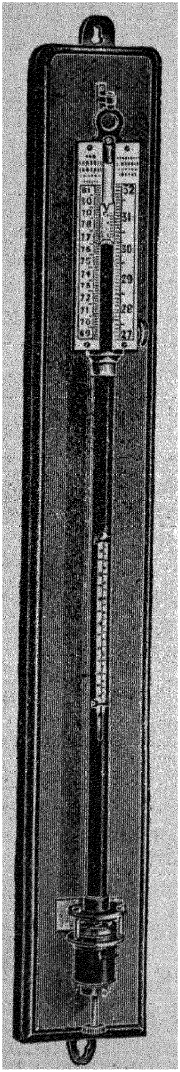


FIG. 42.

known liquid is generally selected. A mercurial barometer consists of a glass tube (about 33 in. long), closed at one end, filled with mercury and inverted into a trough or cistern also filled with mercury. The pressure of the atmosphere at the sea-level on the surface of the mercury in the trough supports the mercury in the tube to a height of about 30 in. The mercury in the tube will fall when the pressure is diminished as in mountain ascent, and will rise with the increase.

In order to obtain a greater accuracy **Fortin's standard barometer** (Fig. 42) is now used. In this the cistern is made with a pliable base of leather which can be raised or lowered by means of a screw. The upper portion of the cistern is made of glass through which the zero of the scale can be seen as a piece of ivory, the lower end of which is called the *fiducial point.* Before taking a reading the level of the mercury in the cistern must be so adjusted as to correspond to this point, which is the zero of the scale, by means of the screw. To obtain a more accurate reading a sliding scale of vernier is attached. The vernier is so graduated that twenty-five of its divisions correspond to twenty-four half-tenth divisions on the barometer scale. Therefore each division on the vernier is $\frac{1}{25}$th less than a half-tenth division on the barometer scale, and is therefore $\frac{1}{25}$th of $\frac{1}{20}$ in. ($=\frac{1}{500}$ or 0.002 in.).

Method of reading Fortin's Barometer.—Adjust the vernier by means of the rack and pinion at the side of the barometer so as to bring its two lower

edges on a level with the convex surface of the mercury and count the number of divisions on the vernier from below upwards until a line on the vernier is exactly continuous with a line on the barometer scale. Multiply the number on the vernier so obtained by 0.002, and the product is the number in thousandths of an inch.

The barometer must be properly fixed in a well-lighted room and protected from the sun, rain, and wind. Corrections must be made by Glaisher's tables for temperature above 32° F., as mercury expands with the rise of temperature. If observations are taken at an altitude an allowance for about $\frac{1}{1000}$th in. for every foot of ascent above the sea-level must be made.

Aneroid Barometers.—These are so-called as no fluid enters into their construction. They are small watch-shaped metallic vacuum boxes. The box is closed by a metal lid which being elastic is acted on by changes in the atmospheric pressure. By an arrangement of levers the movements of the metal are made to turn an index and are recorded on a dial. This instrument is mainly used for recording altitudes and it is customary to read the nearest $\frac{1}{100}$th of an inch both before and after an ascent and then to deduct one reading from the other without taking into consideration the decimal points and above sea-level in feet.

Barometric Fluctuations.—These may occur from variations in the atmospheric pressure which may be regular or irregular. The former is diurnal or annual, while the latter is cyclonic or anticyclonic. A fall in the barometer indicates either that the air is hot or that it is highly moist. Moreover, the pressure falls when the air, as in certain varieties of winds, moves upwards. On the other hand, a rise in the barómeter shows that the air is either cold, or dense, or dry. Diurnal fluctuations are best observed in the tropics where the average range is about $\frac{1}{10}$th of an inch; the maximum occurring at 9 A.M., and again at 9 or 10 P.M.

The *annual variations* are in considerable excess over the diurnal ranges. In the equatorial region where the temperature and moisture remain almost constant through-

out the year, the variation in the mean pressure is slight. The average pressure in Calcutta during July is 29.538 in. and in January 30.022 in., thus giving a difference of 0.484 in. This is due to great heat in July coupled with the heavy rains accompanying the south-west monsoon.

The changes in weather over a wide area brought on by daily, monthly, and annual irregular variations of the barometric pressure are principally divided into *anti-cyclonic*, if the weather is good, and *cyclonic* if the weather is bad. Nowadays barometric readings at a given time over an extended area are telegraphed to a central station to be recorded. If observations of stations having the same barometric pressure are recorded on a map we get a *synoptic map*, and the lines connecting such places or stations are called *isobars*, which arrange themselves in certain typical forms associated with certain kinds of weather. There are seven different kinds of isobars, viz., (1) cyclones, (2) secondary cyclones, (3) anti-cyclones, (4) V-shaped depressions, (5) wedge-shaped isobars, (6) cols, and (7) straight isobars.

III. Movement of Wind

Wind is the effect of disturbances of equilibrium constantly proceeding in the freely mobile atmosphere; the causes of these disturbances being differences in atmospheric pressure brought about by changes in temperature and moisture, aided by physical and other factors. Winds carry with them the temperature of air they have traversed, while the amount of moisture which they can hold increases with the temperature. In all parts of the world the lower current of air moves more slowly than the upper. During the day the lower strata on being heated ascend increasing the friction between the upper and lower currents and reducing the velocity. On the surface of the earth near the equator and all over the sea there is little or no diurnal variation either in direction or speed. On the plains or on high altitudes the wind moves with the hands of a clock, and attains its maximum

strength during the afternoon, backing and diminishing again at night in the northern hemisphere (Notter and Firth). On mountain peaks the wind moves against the hands of a clock, the maximum being attained at night.

The primary factor in the meteorology of India is alteration of seasons. The north-east and south-west trade winds are set in motion by the movement of the earth and are due to the incessant movement of cold air from the poles, replacing the heated air of the tropics. The south-west and north-east monsoons are seasonal. The south-west monsoon is a season of winds of oceanic origin of high humidity and of frequent and heavy rains over nearly the whole of India. The north-east monsoon, on the other hand, is of continental origin, and is therefore dry except where it has travelled over some sea. Hence the north-east monsoon in India is characterised by clear lightly clouded skies with occasional rain. These are therefore more appropriately termed *wet* and *dry* monsoons, suggesting as they do the most important and prominent features of the seasons in the land area of India. In fact about 90 per cent. of the annual rainfall of India occurs during the south-west monsoon. The dry monsoon is again divided into two periods—one of comparatively low and the other of increasing and high temperature. The wet monsoon is similarly subdivided into two periods—June to September is the *monsoon proper*, while October to December is called the *retreating* monsoon. During the cold weather period India is characterised by clear sky, fine weather, large diurnal range of temperature, and light land winds. The months of November and December are the pleasantest of the year in Northern India.

Anemometer.—The pressure and velocity of wind are recorded by instruments called anemometers, of which there are several kinds. Robinson's wind anemometer being considered the best. It consists of a metal cross provided with hollow hemispherical cups at their ends, and revolving horizontally on a vertical axis which, by an arrangement of a screw, records the movements on the

dial. From the number of turns made in a given time the velocity of the wind is deduced.

The cups move at a rate equal to only one-third that of the wind, and allowance is therefore made for graduating the instrument. The instrument should be kept clean and properly oiled, and fixed at least 20 ft. from the ground.

IV. Atmospheric Humidity

Water is being constantly evaporated into the air ; and the atmosphere is more or less charged with aqueous vapour ; the amount of moisture which the air can hold varies considerably not only with the temperature but with the season, and with the elevation and position. During the height of the wet monsoon, it is about 10 to 12 grains per cubic foot in the coast districts of Bengal and Bombay. It is usual to speak of the amount of moisture present in the air as the *degree of humidity*. The amount of moisture present in a given volume of air is called *absolute* humidity, whereas *relative* humidity indicates the percentage of the amount of moisture that is required to cause saturation. If the saturated air be cooled down it will reach a temperature at which the moisture will condense and fall on the earth as rain, hail, mist, or dew. The precipitation of moisture on the surface of the earth or on grass, leaves, etc., is called *dew*, and is caused by the air coming in contact with the cold surface of the earth at night and parting with its moisture from loss of temperature. When the temperature rises again the dew disappears, and the mean of the temperatures of appearance and disappearance is the *dew point*. The dew point is determined by means of a hygrometer, and is roughly calculated by means of a dry and wet bulb thermometer. Glaisher's method gives more accurate results.

Relative Humidity.—This is merely a convenient term used to express comparative dryness or moisture. Complete saturation being assumed to be 100, any degree of dryness may be expressed as a percentage of this, and is obtained at once by dividing the weight of vapour actually existing by the weight of vapour which would have been

present had the air been saturated. In other words, the hygrometric state or relative humidity (H) may be expressed as the ratio of the elastic force of aqueous vapour at the temperature of the air (E) to the elastic force of the vapour at the temperature of the dew point (e); that is $H = \frac{e}{E} \times 100$.—(Notter and Firth). In Calcutta the relative humidity varies from 80 to 93.

Hygrometers.—The amount of moisture present in the air is registered by the *hygrometer*, of which there are two kinds, viz., the *direct* and the *indirect* hygrometers.

Daniell's Hygrometer.—This consists of a glass tube bent twice with a bulb at each end, one being placed at a lower level than the other. The lower bulb is partly filled with ether and a thermometer dips into it. The other bulb as well as the remaining portion of the tube contains ether vapour. The empty bulb is covered with muslin which is kept moist with ether. The ether in evaporating cools the bulb and the loss of temperature so brought about condenses the ether vapour inside the bulb and tube, which in its turn causes an evaporation of the ether inside the lower bulb. Thus the lower bulb cools down and reduces the temperature of the air around it until it becomes so low that it forces the air to part with some of its moisture which condenses upon the surface of the bulb. As soon as this happens the temperature from the attached thermometer is read off and recorded as the dew point.

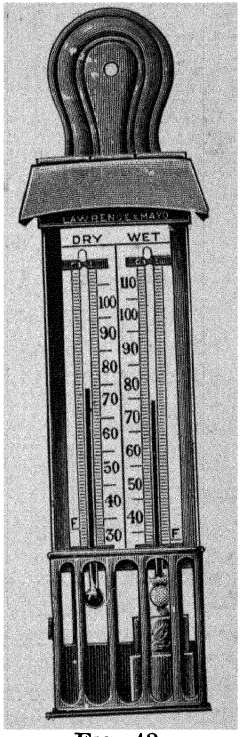


FIG. 43.
WET AND DRY BULB THERMOMETER.

Wet and Dry Bulb Hygrometer.—This instrument consists of two thermometers mounted side by side on a stand, and is used to determine the pressure of the

aqueous vapour in the air. The wet bulb is kept constantly moist by means of a piece of muslin wrapped round it and dipping into a small vessel of water. The water in evaporating absorbs heat from the thermometer with the result that the temperature indicated by this thermometer is much lower than that given by the dry one. The difference in the two thermometers, however, depends on the rapidity with which the evaporation proceeds, and the rate of evaporation depends on the temperature and humidity present. In dry air evaporation being rapid heat will be absorbed from the thermometer at a greater rate and the temperature of the wet bulb will be much below that of the dry one. The instrument should be kept in the shade and protected from air currents and direct sun shine.

V. Atmospheric ozone

It is popularly believed that the presence of ozone in the air is conducive to health, but this requires further confirmation. Potassium iodide and starch papers are used for the detection of the presence of ozone in the air, but they are not reliable, as other substances especially nitrous acid turn them blue.

VI. Sunshine

The duration of sunshine influences the climate to a great extent and is recorded by means of Campbell-Stokes sunshine recorder. It consists of a glass sphere on which the rays fall and the image is received on a strip of mill-board at the proper focal distance. When the sun shines the rays are focussed upon the mill-board or on some sensitive paper leaving a record or a mark behind. But this does not occur when the sun sets or is hidden by clouds. The results are best expressed in percentage of sunshine, *i.e.* if the sun is above the horizon for eight hours and the record is but two hours, the sunshine equals 25 per cent. of the possible amount.

VII. Atmospheric Electricity

The atmosphere is always charged with electricity, and many hypotheses have been put forward to explain its presence. It has been ascribed to (1) growth of vegetation, (2) evaporation of water containing salts in solution, (3) friction of the air against the ground, and (4) combustion. The fact that powerful atmospheric phenomena are accompanied by rain and hail seems to suggest a connection between the excitation of electricity and condensation of aqueous vapour. When the sky is cloudy the electricity is sometimes positive and sometimes negative. It is nearly always positive in fine weather. The electricity of the ground is always negative but differs with the humidity and temperature of the air.

VIII. Rainfall

When the temperature of the air charged with moisture is suddenly reduced either by its ascent into the higher and colder regions or by coming in contact with a cold surface as the ridge of a mountain, or a colder surface of the earth, or a large sheet of water, condensation of the vapour takes place. By constant condensation of aqueous vapour these minute particles of vapour become larger and heavier and uniting form regular drops which fall as *rain*. The amount of rain which falls in different countries varies with the local circumstances, and other things being equal, most rain falls in tropical countries where evaporation is abundant ; in fact rainfall diminishes from the equator to the poles. Under similar conditions the quantity of rain decreases with the distance from the sea and increases with the height above sea-level. The average rainfall during the south-west monsoon in the coast districts of the Konkan is about 100 in. and increases up to about 300 in. on the summit of the hills at an elevation of 3000 ft. to 4000 ft. Sylhet at the foot of the Assam hills has an average total of 157 in., while, Cheerapoonjee on the Assam hills at an elevation of about 4000 ft. has an average of 458 in. The following is a statement of mean or normal rainfall in India derived from the average of

about 2000 stations distributed over the whole country :—

Cold weather (January to February)	0.99	Inches
Hot weather (March to May)	4.58	,,
S. W. monsoon (June to September)	34.65	,,
Retreating S. W. monsoon (Oct. to Dec.)	4.95	,,

It appears that of the mean annual rainfall 12 per cent. occurs during the dry and 88 per cent. during the wet season, but the ratio differs in different parts of India, varying for the dry season from 3 per cent. in Bombay to 19 per cent. in Bengal, 21 per cent. in the Punjab and 30 per cent. in Assam.

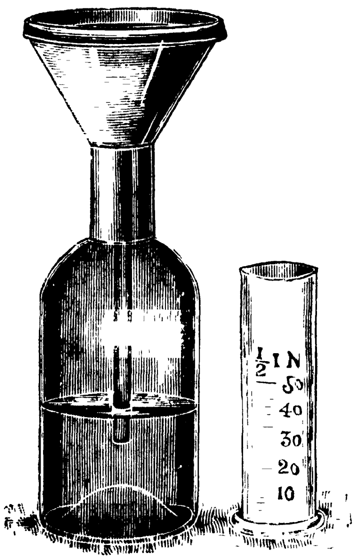


FIG. 44.—RAIN GAUGE.

The rainfall during the cold weather is due chiefly to disturbance in condensation in an upper current ; it is very irregular in its occurrence. The cold weather rainfall, small though it may be, is of great economic value especially over a large part of northern and central India, as upon it the winter crops of non-irrigated districts depend.

The hot weather rainfall presents much greater contrasts. This rainfall is often accompanied by dust storms and is small in amount averaging only about 1 in. accompanied by thunder-storms of great violence and intensity especially in Assam, Bengal, Arrakan, Lower and Upper Burmah. It is of great value for the tea crops in Assam where it averages 31 in., and in Bengal it favours the early spring crops of rice.

Rainfall is measured by a *rain-gauge* which consists of a copper funnel leading to a receiver. The funnel has

* Imperial Gazeteer of India.

a sharp rim and is usually 5 in. in diameter. The rain having been collected into the receiver is measured in a glass vessel graduated to correspond with $\frac{1}{100}$th of an inch of rainfall. The reading is generally taken at 9 A.M. daily, and the instrument is placed on the ground in an open place with the rim about 1 ft. above the earth. In time of snow, melt the collected snow by adding a known quantity of warm water to it, and the extra water derived from snow is counted as rain water. Roughly, 1 ft. of snow may be taken to represent an inch of rain.

IX. Clouds

A *cloud* may be defined as a mass of vapour condensed into minute water particles which float in the air, differing from mists and fogs in occupying the higher regions of the atmosphere. A cloud is therefore a fog at a greater height. A *cloud line* is the level below which the formation of cloud rarely takes place. Clouds have been classified by Hildebransson and Abercromby as follows :

A. Highest clouds, mean height 9000 meters.
- (*a*) 1. Cirrus.
- (*b*) 2. Cirro-stratus.

B. Clouds of mean altitude, 3000 to 7000 meters.
- 3. Cirro-cumulus.
- (*a*) 4. Alto-cumulus.
- (*b*) 5. Alto-stratus.

C. Low clouds, below 2000 meters.
- (*a*) 6. Strato-cumulus.
- (*b*) 7. Nimbus.

D. Clouds formed by diurnal ascending currents.
- 8. Cumulus. Top, 1800 meters ; base, 1400 meters.
- 9. Cumulo-nimbus. Top, 3000 to 8000 metres ; base, 1400 metres.

E. Elevated fog, below 1000 metres.
- 10. Stratus.

Those marked (*a*) are detached or rounded forms, most frequently seen in dry weather ; those marked (*b*) are widespread or veil-like forms, most frequently seen in wet weather.

CHAPTER XVII

INFECTION AND CARRIERS OF INFECTION

By *infection* is understood the introduction into the body, without contact with the patient, of some pathogenic micro-organisms which are capable of multiplying within it at the expense of the host. Diseases therefore depending on such an infection are known as " infective " diseases, and are transmissible in most instances by inoculation. If the micro-organisms are from time to time discharged from the body of the host, either with the excreta, secretions, or in some other way, the disease becomes " infectious " or " contagious," according to the case with which another person becomes infected, and the material which carries the infection is termed the " contagion." Thus in smallpox contagion is conveyed from person to person through the air and this is therefore an infectious disease. Ringworm and syphilis require close contact for infection to take place and are therefore contagious diseases. In other instances, *e.g.*, malaria, infection is conveyed by an intermediary. Although it is customary to draw a line of demarcation between infection and contagion, broadly speaking they are much the same, and according to the modern sense of the term the so-called contagious diseases are infectious. All diseases depending on the entrance of a living organism may conveniently be classed as infectious. *Fomites* are substances capable of absorbing, retaining or transfering infection. They refer to inanimate objects like bedding, clothing, etc.

Infection may be *general* or *local.* In tetanus and diphtheria, the organisms after infection cause some local disturbance and cannot be detected in the circulation. In enteric fever, the germs are present in the general circulation. In both instances, however, the constitutional

changes are due to the toxins and not to the germs themselves.

Some persons are peculiarly susceptible to certain diseases, others offer some resistance to infection. This susceptibility is called *predisposition*, which may be natural, artificial, or acquired, and the resistance, as opposed to predisposition, is known as *immunity*. The liability to infection also varies in man according to age, sex, climate, season, locality and surroundings. It must be observed that susceptibility of the tissues varies greatly, and that infection or invasion of the body by bacteria does not occur every time the body is exposed.

Certain terms are used to express the relative prevalence of infective diseases ; they are ; (*a*) *Epidemic*—when a number of cases break out by infection from a common source at one time and the outbreak is then followed by a period of rest. (*b*) *Endemic*—when a disease is constantly present in a certain district and is peculiar to the district or locality. Endemic diseases sometimes flare up and become epidemic. (*c*) *Sporadic*—when a disease occurs only in isolated cases. (*d*) *Pandemic*—when the epidemic is spread over a large area or over the whole world.

Incubation.—The characteristic feature of an infection is that the disease runs a definite course. After infection the germ remains latent, and the person does not develop any symptoms for a time. This latent period is called the " stage of incubation." The duration of this period varies, each case differing from every other, and depends partly on the amount of poison entering the system at the time of infection, and also on the resistance offered by the individual. During this period the patient may remain perfectly healthy or may feel a little malaise. It has been shown that in typhoid and cholera the specific bacilli continue to be discharged from the body for a much longer time than is ordinarily supposed. During this incubation period a person exposed to an infection requires to be isolated or placed in quarantine. This is of great value in considering measures for the suppression of infectious diseases.

The following table gives an approximate statement of the period of incubation and the duration of the communicability of some of the most important microbic diseases :—

Disease	Incubation period	Infective period.
Chicken pox	10 to 12 days	3 weeks
Cholera	a few hours to 5 days	2 ,,
Dengue	3 to 6 days	2 ,,
Diphtheria ..	1 to 8 ,,	6 ,,
Enteric Fever ..	5 to 20 ,,	6 ,,
Influenza	1 to 4 ,,	2 ,,
Measles ..	8 to 15 ,,	4 ,,
Mumps	12 to 22 ,,	3 ,,
Plague	3 to 10 ,,	3 ,,
Smallpox . .	12 ,,	6 ,,
Whooping Cough . .	4 to 14 ,,	8 ,,

Bacteria.—Bacteria or *Schizomycetes* are minute vegetable-organisms which are the active causes of infective diseases. They are devoid of chlorophyll and multiply by simple transverse division or fission and are thus distinguished from the yeasts where multiplication takes place by budding or gemmation. The size of bacteria varies, but they are all microscopic, measuring from 0.3 μ to 30 to 40 μ in diameter or length. Some bacteria are motionless while others are more or less motile, but even in these there is a resting stage. The shape is also very different ; some are spherical, others ovoid, others rod-shaped, etc., and they have been classed into three main groups according to their shape ;

(i) Cocci—when of rounded shape.
(ii) Bacilli—when rod-shaped.
(iii) Spirilla—when curved or spiral.

According to whether bacteria thrive upon living or dead matter as well as according to their most characteristic effects they have been classified for the sake of convenience into *zymogenic* (fermentative), *aerogenic* (gas producing), *saprogenic* (putrefactive), *toxicogenic* (poison-producing), and *pathogenic* (disease producing) organisms. According to whether the organisms grow in the presence or absence of oxygen they are classed as *aerobes* and *anaerobes*. Some are *facultative, i.e.* capable of multiplying

under either one of the other condition. Some bacteria are harmless both to animals and plants, and apparently under no circumstances give rise to disease in either. These are known as *saprophytes*. Others again live on the bodies of plants or animals and produce disease; these are known as *parasitic* or *pathogenic* bacteria.

Each bacterium has the property when introduced into the body of manufacturing toxins peculiar to itself, and the distinguishing symptoms of a disease are due more to the toxins than to the presence of the bacillus itself. How the toxin is produced is a debatable point. Some hold that it is formed from the cell-plasma of the bacillus, others regard it as the product of the action of the bacillus on the protein substances. The functions of the body may therefore be disturbed by the bacteria in two ways: (1) through the absorption of their excreted toxins or by the changes wrought on the proteins by these toxins (simple intoxication, as in cholera), (2) by their growth and the production of toxins within the body (infection, as in typhoid fever).

Modes of Infection.—Micro-organisms may be introduced into the human body in a variety of ways, viz. inoculation, inhalation, ingestion, absorption, carriers and insects.

1. *Inoculation.*—Generally the contagia of glanders, anthrax, vaccinia, tetanus and rabies are thus received. Abrasion facilitates infection from syphilis, gonorrhœa, etc.

2. *Inhalation.*—The chief source of infection by inhalation is through air-pollution. The air was long regarded as the medium through which many infective organisms are carried. This idea has within recent years been modified to a great extent, and only diseases which may be called air-borne are perhaps small-pox and measles. Outside air contains relatively few bacteria, where they are considerably diluted, and most of the organisms pathogenic to man die when exposed to sunlight. But the air of ill-ventilated houses and crowded places is often surcharged with different pathogenic bacteria. For instance, tram-cars, ill-ventilated school rooms, offices,

etc., in crowded places often contain micro-organisms of diphtheria, whooping cough, measles, influenza, cold, tuberculosis, etc., in sufficient concentration to infect others exposed to these surroundings. During sneezing, coughing, speaking and other expiratory efforts the fluid contents of the mouth are sprayed into the air in minute particles. These droplets contain the germs of any infection that may be in the mouth. This mode of infection is known as "droplet infection."

3. *Ingestion.*—Quite a large number of infections are conveyed from person to person indirectly through the medium of water, food, insects, etc., of these water or food when contaminated often carries infection and causes epidemic outbreaks. Enteric fever, cholera, and dysentery are, as a rule, produced through infection of milk, water, or other food.

4. *Absorption.*—This happens with mucous surfaces as in venereal diseases. In diphtheria the microbe is arrested in the nasal or pharyngeal mucous membrane.

5. *Carriers.*—A carrier is a person who harbours a pathogenic organism without showing any sign of the disease. Thus a person may be a cholera carrier or a typhoid carrier without giving evidence of any symptoms of these diseases. Similarly a person may be a diphtheria carrier. Carriers may be acute, chronic or temporary. Acute carriers harbour the micro-organisms for a few weeks after convalescence ; chronic carriers continue to harbour the organisms for months and years ; and temporary carriers harbour and discharge pathogenic organisms for a short time only but without suffering from the disease. The detection of carriers is of great value since it enables one to take proper preventive measures. A cholera or typhoid carrier should not be allowed to handle food or employed in the kitchen.

6. INSECTS

Sir Ronald Ross first drew attention to the important part insects play in the transmission of diseases.

Malaria, enteric fever, yellow fever, plague, filariasis, sleeping sickness, kala-azar, etc., are all caused through the agency of insects.

The size of insects varies from $\frac{1}{50}$th to 6 in., and they live from a few days to as long as over ten years, but they rarely live more than three years, and in the majority of them their active lives are limited to only three months. They live wherever nutriment is available, on land as also in fresh water, and even in the bodies of warm-blooded animals and man.

Insects are intimately related to man ; except perhaps the domestic animals no single group of animal life enters more into the daily life of man than insects. " They live on us and around us ; in our food, our clothes, our furniture, our houses ; we eat them or their products, we collect them and sew them on our clothing." There are insects that are useful, but there are many that affect man in other ways.

The rôle played by ticks, biting flies, and other blood-sucking parasites in the transmission of various diseases to mammalia is one of economic importance. The malarial mosquito, a constant scourge of tropical and semi-tropical countries, has been shown, to be a factor in the life history of great nations. The plague flea has taken its toll of millions from the human race. Africa the greatest of all the continents, lies under the ban of trypanosome-transmitting biting flies such as the tsetses. Over half a million of human beings have died during the last ten years from fly-borne sleeping sickness, whilst examination of a large number of villages by competent observers has shown that 30 to 50 per cent. of the inhabitants in these infected areas must sooner or later succumb to this disease. Thus it will be seen that these invertebrate parasites affect the economics of the present and succeeding generations profoundly.*

The ways or means by which insects may carry the germs of disease from one place to another are to be carefully considered. They may act as *passive agents* : may

* Carter, *Bombay Medical Congress*, 1909.

simply convey the infection on their contaminated bodies or in their excreta. This transmission is purely mechanical and it is immaterial by what kind of insect it is effected. But the chief interest centres at the present time on the part the blood-sucking insects play in the propagation of different parasitic diseases. It will be observed that parasites can infect a healthy animal only by direct inoculation, and in the absence of blood-sucking insects it is difficult to understand how this can very often occur. A blood-sucking insect therefore affords a ready means of introducing a blood-parasite from one animal into another. But it is still debated whether the parasite is carried from one animal to another in a simple " mechanical " way undergoing no change, *en route*, or whether, as in the case of anopheline mosquitoes, the parasite undergoes a series of changes before it is in a fit state again to infect a healthy animal's blood.

The blood-sucking species of insects belong exclusively to two orders, *Diptera* to which belong the mosquitoes, sandflies, midges, and the house flies, and *Rhynchota* to which belong the bugs and the lice. The face mite, itch insects, and the tick, although strictly speaking they cannot be classed as insects and are known as *Arachnida*, are also of interest to us inasmuch as they act as agents in transmitting certain diseases. Ticks are responsible for the propagation of relapsing fever.

General Characters of Insects.—The bodies of insects are covered with a tough skin and divided into three distinct parts : the head provided with two antennæ or horns, and eyes and mouth of variable form : the trunk or thorax composed of three segments which has underneath it always six articulated limbs, and often above it two or four wings : and an abdomen composed of nine segments some of which may be difficult to recognise. In addition to these characteristics they are not provided with interior skeletons and their nervous system is formed of a double cord, swelling at intervals, and placed under the head and along the underside of the body. Insects are not provided with lungs but breathe by particular organs termed *tracheæ*, extending parallel to each other along

each side of the body, and communicating with the exterior air by lateral openings called *spiracles*. The sexes of all insects are distinct and they are reproduced from eggs (Lukis and Blackham).

The following is a list of insects classified by Balfour and Archibald and the diseases they are known, or supposed, to transfer :—

1. *Ants*.—These insects may readily convey all the diseases due to contamination of food, such as cholera, dysentery, and enteric. There is no definite proof that ants act as carriers, but considering their habits in tropical countries, it is far from unlikely.

2. *Bed-bugs*.—These loathsome insects are charged with the conveyance of anthrax, kala-azar, leprosy, some skin diseases, tuberculosis, typhus fever, and yaws.

3. ***Fleas***.—It has been definitely proved that plague is conveyed by fleas.

4. ***Non-biting Flies***.—The list of diseases laid to the door of what Sir Rupert Boyce calls the Septic Fly is a long one ; it includes :—(1) anthrax, (2) eye diseases, (3) cholera, (4) diarrhœa, (5) dysentery, (6) enteric fever, (7) maggots in wounds, (8) leprosy, (9) oriental sore and other skin diseases, and (10) consumption.

5. ***Biting Flies, apart from mosquitoes and sandflies***.—The tsetse fly conveys sleeping sickness. Sambon has shown that pellagra is conveyed by midges.

6. ***Mosquitoes***.—These insects are the sole agents for the spread of malaria and yellow fever. "No mosquitoes, no malaria" is a universally accepted sanitary dogma of to-day.

7. ***Sandflies***.—These insects have been shown to convey the three and five-day fevers which are common all over India.

8. ***The Itch Insect***.—This is a member of the spider family which, in addition to causing the disease known as "itch," is charged with conveying leprosy and skin diseases.

9. ***The Face Mite***.—The distressing complaint known as *acne* is attributed to this small animal parasite.

10. *Ticks.*—These pests are the agents for the conveyance of a large number of diseases of animals, and it has recently been shown that in Africa, they convey the germ of a fever which closely resembles the relapsing fever of India—a disease now known to be conveyed by the ordinary "pediculi" or "body lice."

11. *Lice.*—Body lice are said to convey tubercle, leprosy, typhus, and relapsing fever.

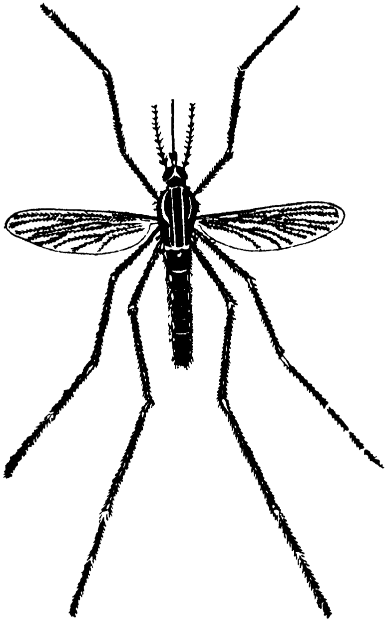


FIG. 45.—STEGOMYIA CALOPUS.

MOSQUITO OR GNAT

The mosquito belongs to the order *Diptera* and family *Culicidæ.* Like all the members of this group it lays eggs from which is hatched a worm-like larva, which afterwards, becomes converted into a *nymph* or *pupa,* from which the adult mosquito emerges. The egg, the larval, and the pupal stages are spent in water, and therefore water is essential for the existence of all mosquitoes. The adult mosquito has a rounded head with prominent eyes, two antennæ, two palpi, and a prominent suctorial and piercing organ—the proboscis, an oval chest about the size of the head to which are attached a pair of membranous wings and three pairs of jointed legs. The abdomen is segmented.

The species of mosquitoes that are important to a medical man are the anopheles, culex, and stegomyia. The *anopheline* transmits the malarial parasite from man to man. The *culicinæ* are responsible for the propaga-

tion of filaria, *Stegomyia calopus* disseminates the micro-organisms of yellow fever, and *Stegomyia pseudoscutillaris* acts as an intermediary host of *Filaria bancrofti.*

S. calopus, the species responsible for transmission of yellow fever and dengue breeds in small artificial collections of water, such as barrels, puddles, cisterns, etc. The eggs resist considerable degree of drying and as they may sink to the bottom of the water in which they lie, are liable to be pumped up into water reservoirs.

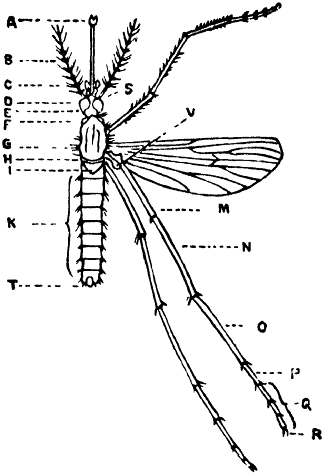


FIG. 46.—MOSQUITO.

A. Proboscis ; B. Antennæ , C. Palpi ; D. Eyes ; E Vertex ; F. Occiput ; G. Mesothorax ; H. Scutellum ; I. Metathorax ; K. Abdomen ; M. Femur ; N. Tibia ; O First tarsal ; P and Q. Tarsal segments ; R. Ungues ; S. Front ; T. Egg depositor ; V. Haltere.

The *Stegomyia* is a purely domestic mosquito, rarely found far away from towns and villages and like other brightly coloured mosquitoes it bites chiefly during the day and only occasionally at night. The females are blood-suckers. Each female lays from twenty to seventy-five eggs separately, instead of being cemented together to form rafts, as in other culicinæ, on the surface of the water. These are very minute, black, cigar-shaped, and most resistant ; they are generally found in cisterns or rain-water barrels. The Stegomyia is recognised by the broad,flat, imbricated scales completely covering the head and abdomen, and which are invariably present on the middle lobe and frequently also on the lateral lobes of the scutellum. The scales giving a satiny appearance which is characteristic. It is a beautiful insect strikingly marked with black and white, and the most characteristic feature by which it is differentiated from every other mosquito is the lyre shaped white mark on the thorax.

Anopheles and Culex.—The eggs are laid on the surface of the water near the edge of the tank, etc., and are held together by a sort of gummy material which surrounds them.

In the case of culex, hundreds of eggs are cemented together to form rafts which are about the size of caraway seeds and of a brownish-black colour. While in the anopheles each one remains separate and has an air cell which helps it to float. The anopheles female

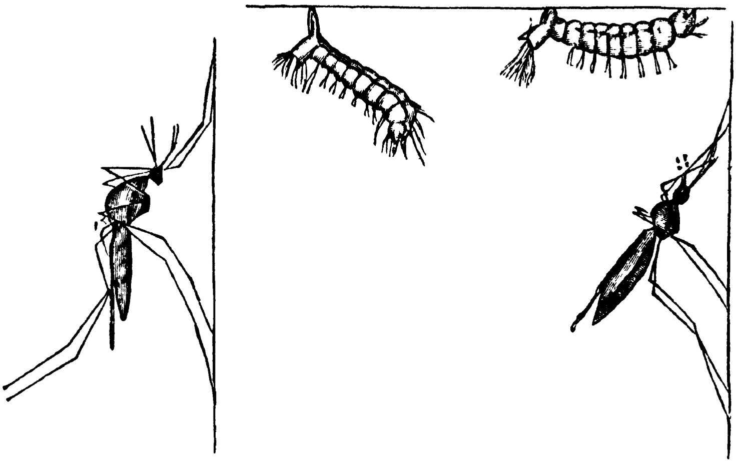


FIG. 47.

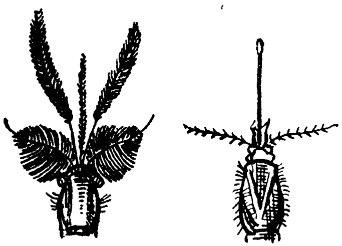
Culex larva in breathing position on the surface of water; resting position of adult culex. | Anopheline larva, showing breathing position on the surface of water, resting position of adult anopheline mosquito.

lays from 100 to 150 eggs on the edge of the tank on the wet mud. They are cigar-shaped and white in colour when first laid, but changes rapidly into black.

In about three days the larvæ emerge from the under side of the eggs and are big enough to be seen by the naked eye. The larva swims actively about the water, and has a flattened head with a pair of big eyes, rectangular thorax studded with bristles, and a segmented abdomen with

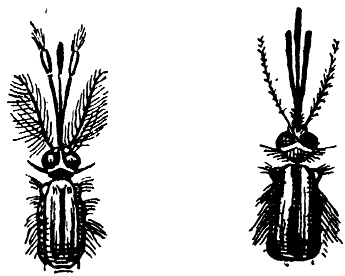
several lateral bristles. There are also two curious structures at the posterior half of the abdomen—one is a sort of fin, while the other is an air-aperture protected by valves which open and close as required.

The position of the larva in water during breathing depends on the arrangement of the air apertures. In anopheles the apertures are close to the surface of the body and so the larvæ lie horizontally beneath the surface of the water. The culicinæ larvæ are supported by the syphon fringe, while their head and body hang down. Small fishes have a natural tendency to live on larvæ, which protect themselves by taking shelter in the aquatic



1 2

FIG. 48.—HEADS OF CULEX 1 Male ; 2, Female.



3 4

FIG. 49.—HEADS OF ANOPHELINE 3, Male ; 4, Female.

weeds. The larvæ are very voracious and live on small aquatic plants and animals not excluding their own kind. They cast their skins several times before they reach full development. The stegomyia larvæ are longer than those of culex, they have a smaller head and less prominent thorax, and their attitude is almost vertical. To protect themselves from fish, they hide in the weeds and grass on the edge of the tanks, and therefore the tanks should always be kept free from weeds.

In about 8 to 10 days the larva develops fully, and a new creature, known as *pupa*, is formed out of it. It is shaped like a comma and is lighter than the water on which it floats and it moves about actively. It has no mouth and

therefore cannot eat ; it breathes through two small tubes on each side of the thorax. In about 24 to 48 hours the

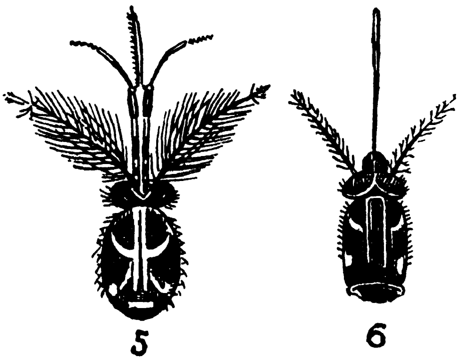


FIG. 50.—HEADS OF STEGOMYIA.
5, Male ; 6, Female.

pupa case splits and the perfect insect or *imago* is hatched out. When the adult mosquito is ready to emerge, the pupa becomes straight and lies flat on the surface, the empty case acting as a raft on which the mosquito rests till its wings have dried.

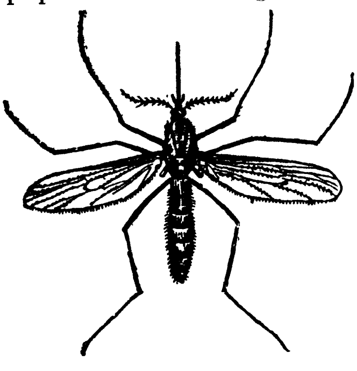


FIG. 51.—CULEX (Female).

Habits of Mosquitoes.—The adult insects, particularly the males, live on vegetable juices, but the females of most species are blood-suckers and so their proboscis is modified for the purpose. The male mosquito therefore takes no part in the spread of disease. The whiskers or plumes on either side of the head of the males distinguish them from the females. The majority of Indian mosquitoes are nocturnal in their habits. They hide themselves

during the day amongst shrubs and bushes, in corners, huts, etc. They generally live in cattle-sheds and stables which are usually ill-lighted and ill-ventilated, and where they get the necessary warmth and food (blood of animals) to live on. It is very often observed that infection generally occurs on spending the night in a malarial

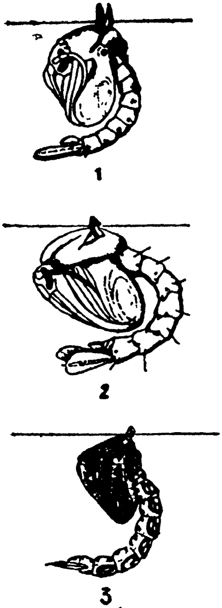


FIG. 52.

PUPÆ OF MOSQUITOES
1, Culex; 2, Anopheles; 3, Stegomyia.

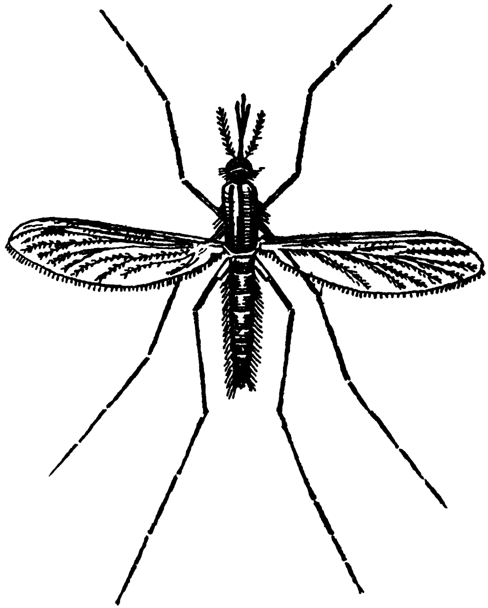


FIG. 53.

ANOPHELES MACULIPENNIS
(Female)

locality or district. Persons paying a flying visit during the day often escape infection.

The larva ceases to grow in winter, and the adult female hibernates in the dark to become active again in the hot season. Each female mosquito lays eggs

several times in a season, and at each time some hundreds; and the fresh ones produce eggs within a week or so after emergence from the pupa case. It takes about a minute or so for the mosquito to fill herself, and with every bite she injects a poison which sets up local irritation and inflammation and helps to keep the blood fluid, thus rendering it more easy of digestion. The plasma of the blood is excreted, leaving the more solid portion in the stomach for digestion, which is effected in one to four days when she is ready for a fresh meal. She always lays eggs after a meal of blood. Some insects of this order closely resemble anopheles in appearance as well as in habits, chief of them are sandflies, and midges.

Breeding-places of Mosquitoes.—It may be said in general that wherever there is a collection of water anopheles breed, although they naturally breed in terrestrial waters, they may likewise breed in any collection of water—in cesspits, iron or masonry tanks, and even in earthenware *chatties*. It should be noted, however, that anophelines are not extensive travellers, and remian at the vicinity in which they were born. Therefore their number decreases as the distance from their breeding-places increases, and it may be concluded that the number in a locality is in inverse ratio to the square of the distance from their breeding-places.

Of the large number of described species of anopheline the following are the principal hosts of the malarial parasites in India: *Myzomyia culicifacies*, *M. turkhudi*, *M. christophersi*, *Pyretophorus jeyporensis*, *Myzorhynchus sinensis*, *Nyssorhynchus fuligenosus*, *N. maculipalpis*, *N. stephensi*, *N. theobaldi* (Manson), *M. listoni*, *Myzorhynchus jamesi* and *M. barbirostris*.

SANDFLY

These flies act as carriers of a special form of disease characterised by fever of short duration, usually lasting from three to five days. The fever was described by Colonel Birt as phlebotomus fever from Malta and Crete.

It also occurs in India in an endemic form in Chitral. There are two distinct species of insects popularly known as sandflies : (1) The *Simulium*, belonging to the family *Simulidæ*, commonly known as Black-flies or Buffalo-gnats, which are supposed to convey the germ of pellagra, and (2) the *Phelebotomus*, or true Sandflies or Owl-midges.

The Simulidæ.—These are small thick-set, dark-coloured flies, though in hot climates they are sometimes light coloured. They have a hump-backed appearance and are provided with short, thick, cylindrical antennæ

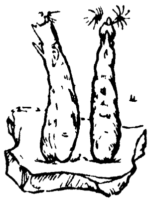


FIG. 54.
LARVÆ OF SIMULIUM.

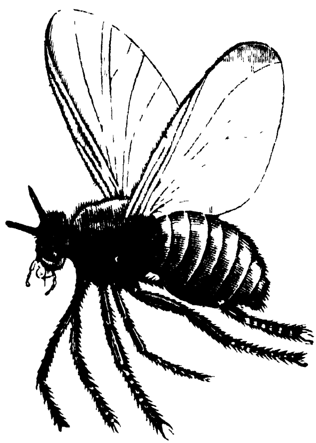


FIG. 55.
THE SIMULIUM.

of eleven segments each. They have a peculiar dancing flight, and the females are blood-suckers. The larvæ live in running waters, they are vermiform with swollen posterior ends, and are provided with two fan shaped cephalic plumes which vibrate in water in the act of conveying food to the mouth. They adhere by their hind part to aquatic herbs and stones, and spin threads which by anchoring them to suitable projections protect them

from being carried away. When full grown a cocoon is formed into which it pupates.

The Phlebotomus.—This includes *Phlebotomus papatasii P. molestus, P. minutus.* Whittingham and Rook (*British Medical Journal* Dec. 15th, 1923) of the Sandfly Commission, made a careful study of the life history and bionomics of *Phlebotomus papatasii.* They have shown that the virus of the sandfly fever is handed on from generation to generation. In fact the fever was transmitted

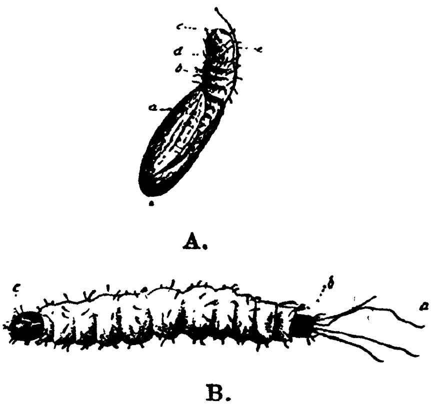


FIG. 56.—A, FERTILISED OVUM. Showing ruptured egg-shell and the larva emerging; B, The Larva of Sand-Fly.

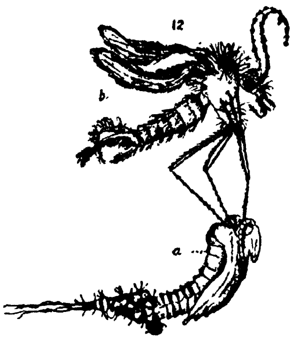


FIG. 57. EMERGENCE OF IMAGO FROM PUPA CASE.

to man by the bites of phlebotomi bred in sterile soil in England. The following description is based on the researches made by Whittingham and Rook.

It is a small midge 8 mm. in length, delicate build, and thickly covered with fine, long hairs. The body is pale lemon tint. The eyes are relatively large, black and conspicuous. The antennæ are long and filiform with sixteen segments. The proboscis is long and contains delicate piercing organs, and on either side of

it are the bushy labial palps which are folded back on themselves, which protect the proboscis. The wings are hairy and lanceolate. They are held erect in a characteristic attitude resembling deer's ears, expect when newly hatched or shortly before death.

The female is recognised by the spindle-shaped abdomen, while in the males the presence of the external genitals gives the posterior extremity of the abdomen the appearance of the tail of an aeroplane.

The Ovum.—It is 0.385 mm. long, 0.12 mm. broad, ovoid dorsally and flattened or slightly concave ventrally. It is moist, glistening and when fresh of a pale yellow colour. It soon becomes opaque, and daily for eight days, changes colour, passing from light to dark brown, and then to sepia. During this period the surface markings on the egg appear. The egg matures in nine to ten days in summer, and under favourable atmospheric conditions the larva emerges within five minutes of the first appearance of the head through the egg-shell. Excessive moisture retards this process and may even cause death. Drying is more injurious than moisture.

The Larva.—This consists of a head and twelve segments. The head is furnished with strong jaws. Throughout the whole larval stage a white Y-shaped mark and a pair of small antennæ are seen on the back of the head (c, Fig. 56. B.). Both the head and the body are filled with short, white or yellow hairs.

For the first five days of life the larva feeds voraciously and rapidly grows in size. The larva goes through a series of moultings, and pupation occurs at the end of the fourth month.

The Pupa.—The length of time between the hatching of the ovum and pupation may be 24 days, and if the insect hibernates, it may be as long as 202 days.

The larva gradually empties its guts for two and three days before pupation. Excess of moisture, or a temperature below 65° F., retards this process. During this time it seeks darkness. The surface of the body looks bloated, dull, wax-blue and semi-transparent, and the insect becomes very sluggish. After several arching

movements the chitinous head covering separates on the dorsum from the rest of the skin and the pupa emerges.

The newly emerged pupa is 5 mm. in length, club-shaped, moist, glistening and of a milk-white colour, The head of the club is formed by the head and the thorax which appear fused in one mass. By the ninth day of pupal life the component parts of the imago are seen, and pigmentation of the eyes and hairs is marked.

The Imago.—The newly hatched imago is white with body and wings covered with long downy hairs. The wings are moist and crumpled up, and held in a horizontal position. When the wings are dry they are raised at an angle of 15° above the body, and the insect is able to fly and feed.

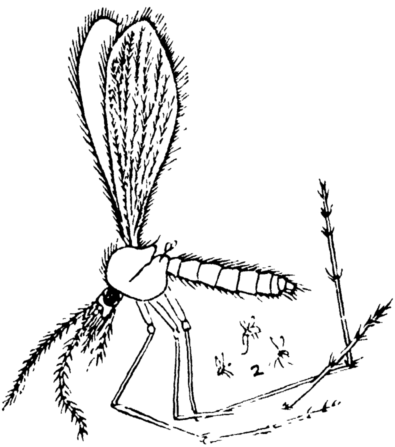


FIG. 58.—FEMALE PHLEBOTOMUS. (2.) SAME NATURAL SIZE.

When disturbed they jump to one side, almost like a flea, a characteristic movement of the sandfly.

Like mosquitoes, the males are harmless, but the females are blood-suckers, and being of a smaller size they have the advantage over mosquitoes in getting through ordinary mosquito netting. They avoid light and bite chiefly at night, and in shady places during the day. They ordinarily bite the wrists and the ankles even through the socks and light clothing. The actual bite is not felt, the pricking sensation is caused by the injection of saliva which takes place a few seconds later. The saliva delays the clotting of blood which is sucked up. They are generally to be found in or near bathrooms, near the floor, under bricks and stones, and in damp, shady places. They breed in places where vegetable organic matter like food refuse is under-going decom-

position, particularly in the drains adjoining cook-houses.

Protection against sandfly is very difficult, and was almost impossible during the last war. Large numbers are killed by fumigation with sulphur or spraying with formalin or cresol. Essential oils, chiefly oil of cassia, are effective as long as the smell lasts. Fine-mesh (22 holes to the linear inch) mosquito net affords a real measure of protection. Good walls and floors, occasional painting and varnishing of all doors and windows are worth trying.

CHIRONOMIDÆ OR MIDGES

These little blood-thirsty insects belong chiefly to the genus *ceratopogon* , they are found in most part of the world, and are very annoying to man. Midges are distinguished from the mosquitoes by their small head, short proboscis, and by the absence of scales on the body and wings and different venation. In their resting attitude they raise the forelegs and hold them up in front of the head, while the mosquitoes raise the hind ones above the thorax and abdomen. They are extremely small flies, males being somewhat larger than females. They are blackish or greyish-brown in colour, with wings often hairy and frequently speckled with greyish-brown blotches. When at rest and wings closed one over the other they look like blades of a pair of scissors. With the exception of one variety, which is terrestrial, all the other species lay eggs in water which pass through the same stages as those of the mosquito. The larvæ of the terrestrial variety feed on rotten vegetable matter.

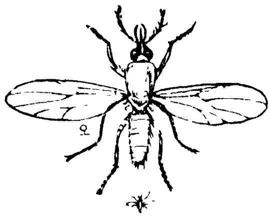


FIG. 59.
MIDGE (Ceratopogon).

Patton has described a new Indian blood-sucking midge, common in Madras, which he has named *Culicoides*

kiefferi. How far these are responsible as carriers of disease is not settled.

Flies

Flies belong to the family *Muscidæ*, and the common house fly and blue bottle are familiar to all. They belong to the order Diptera and are most widely distributed of all insects. The house-fly is quarter of an inch in length, mouse grey in colour, with four narrow black stripes on the thorax. The proboscis ends in a pair of fleshy lobes and when not in use is folded away into a cavity under the head. This proboscis is merely adapted for sucking food and is not capable of piercing the skin.

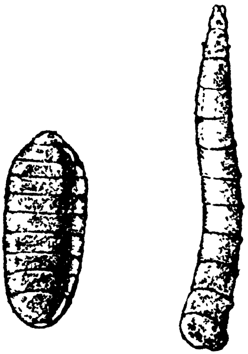


Fig. 60.

The Egg and Larva of House-Fly.

The female deposits her eggs only in materials that will provide food and a home for the maggots. The food material must be capable of being easily swallowed, moist and warm. It cannot breed in perfectly dry material. Normally it breeds in decaying refuse of all sorts, and is especially partial to horse manure. It also breeds freely on human excreta, which makes it very dangerous to human beings, carrying as it does the germs of intestinal diseases. A female house-fly will lay as many as 120 to 500 eggs at a time. Taking the egg batch to be 120 eggs in each case the progeny of a single house-fly will number 432,000 in seven weeks, *i.e.* three generations, taking the time of development from egg to fly as seven days (Austen). Each house-fly passes through the four following stages :—

1. *The Egg or Ovum*—The eggs are glistening white about $\frac{1}{25}$ in. to $\frac{1}{20}$ in. in length and look like tiny grains of polished rice under a fairly strong hand-lens.

They are usually laid one on top of the other. Each female lays from 120 to 150 eggs at a time, and may deposit five or six such batches during its life. Thus each female may produce 600 to 900 eggs. The subsequent development depends upon the temperature of the air, the character and the temperature of the food.

2. *The Larva or Maggot.*—The eggs hatch into tiny white, footless maggots within 8 to 24 hours. They grow rapidly and burrow into the food material on which they feed. They are about ½ in. in length and develop

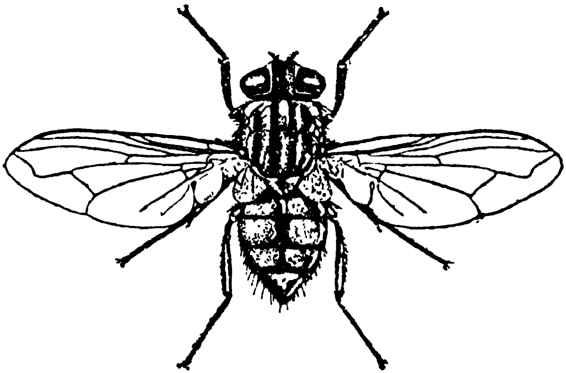


FIG. 61.—THE HOUSE-FLY.

within 2 to 4 or 5 days. The maggots shun the light and disappear during the day time, but come to the surface and move about at night.

3. *The Pupa or Chrysalis.*—The full grown maggot is followed by this stage which extends from 5 to 7 days under favourable conditions, but may extend to four weeks or more. It is passed within a barrel-shaped puparium or shell, usually about ¼ in. in length. It is at first of pale yellow colour, but becomes successively red, brown and finally black.

4. *The Adult Fly.*—The newly hatched fly is lacking in colour and has a wizened or shrunken appearance incapable of flying. It is provided with a sac on the front of its head which by alternate expansion and con-

traction helps the fly to escape from the puparium. The sac is subsequently withdrawn inside the head and cannot be seen any more. The wings spread out soon, the outer covering of the body and legs harden and the fly looks quite normal.

Excepting the important group of blood-sucking muscidæ, flies, as a rule, cannot bite, and therefore are not blood-suckers. They therefore act as carriers of disease in a purely mechanical way. It has been proved that fly is capable of carrying *B. enteritides* (Gaertner) for eight days, *B. prodigiosus* up to seventeen days; *B. tuberculosis* when infected by feeding on tubercular sputum for seven days; *B. anthrax* for five days and spores for atleast twenty days; and *B. diphtheria* for twenty-four hours. Cysts of *E. hystolitica* could be found in the fæces of flies twenty-four hours after a meal on infected fæces. C. Gordon Hewitt states that Prowezek has found a flagellated protozoon allied to the trypanosome in the house-flies which he examined. The discovery of this parasite in the common house-fly is of great importance, since it is believed that kala-azar is due to a species of Herpetomonas.*

No method of sanitation is perfect that does not limit or destroy their breeding-places, and also prevent or limit their access to excreta, and protect articles of diet, both in public and private places, from their contact. The presence of flies—*Musca domestica*—indicates either that there is abundant food or good material for the deposition or hatching of eggs in the vicinity.

A certain number of adult *Muscidæ* bite and suck the blood of man and animals. Their trunk undergoes transformation into a rigid tube of variable length which extends horizontally from the under surface of the head and serves to pierce the skin. The most important of these biting flies are the *Stomoxys calcitrans* which are supposed to act as carriers of poliomyelitis, anthrax, relapsing fever and sarra in animals and epithelioma in fowls, and the tse-tse fly which belongs to the genus *Glossina*, and acts as the carrier of the parasite try-

* J. T. C. Nash, *Bombay Medical Congress*, 1909.

panosome, giving rise to sleeping sickness. It was formerly supposed that the parasites were conveyed in a purely mechanical way, carried in the insects' proboscis, but recent observations by Kleine and Bruce tend to prove that glossina serves as an alternate host in a purely biological sense, and that the trypanosome, after entering the intestinal canal of the insect, undergoes developmental changes which enable it subsequently when opportunity offers to effect a lodgment in some vertebral host.

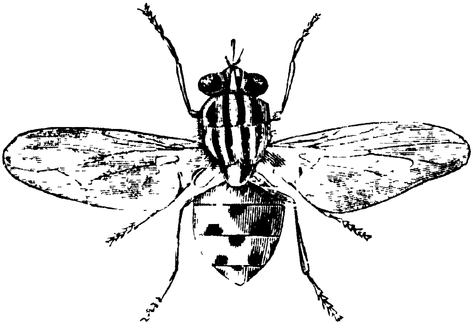


FIG. 62.—STOMOXYS CALCITRANS

The Stomoxes.—In appearance it resembles the domestic fly, from which it is distinguished by the horizontal rigid shining black proboscis projecting like an awl in front of the head. It is non retractile. The *Stomoxys calcitrans* is the common stable-fly. It is found all the world over, living near stables and cattle-sheds. It can be identified by the eyes, kidney shape in profile, and the dark rounded spots in the form of a triangle on the abdominal segments. The palpi are short and not protecting the proboscis, and the wings diverge at an angle when resting. The fly is very voracious blood sucker and never quits inhabited places. The larvæ look like maggots. In the course of two to three weeks they change into pupæ which develop in a fortnight.

The Glossinæ.—The study of tsetse flies and the diseases disseminated by them is not only of scientific interest, but of great practical importance. This is evident from the fact that some thousands of the natives of Uganda have died from sleeping sickness alone—a disease disseminated through the tsetse fly. Austen characterises the tsetse fly as follows :

"Tsetse may be described as an ordinary looking, sombre, brownish or greyish or brown, fly varying in length from 3½ to 4 lines in the case of *Glossina morsitans* to about 5½ lines in that of *Glossina fusca* or *longipennis* with a prominent proboscis in all species. The hinder half of the body or abdomen in the best-known species, though not in all, is of a paler colour and marked with sharply defined dark brown bands, which are interrupted on the middle line ; the abdomen however, is invisible when the insect is at rest, as it is then concealed by the wings. The sexes of tsetse flies can readily be distinguished since in the male the external genitalia form a conspicuous, knob-like protuberance (hypopygium) beneath the end of the abdomen, which is absent in the females." When in a retiring attitude the wings overlap on the back, crossing each other and thus differ from stomoxes and the domestic fly. This not only gives the fly an elongated appearance, but serves to distinguish it from other blood-sucking diptera.

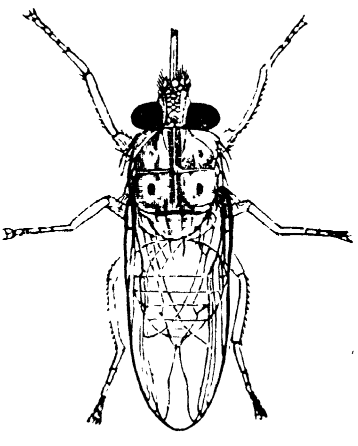


FIG. 63.—TSETSE FLY.

Glossinæ do not lay eggs like most other flies ; the larvæ attain their full growth in the ovary, and after being passed do not feed but pass into the ground and become pupæ. The larvæ are deposited in the vicinity of rotting

vegetation, especially near the roots of plants and trees.

G. palpalis is found in boats and canoes, and frequently it will crawl out and bite the legs ; and as it flies low it often bites either the ankles or the legs, unlike the higher flying *G. morsitans*, which attacks the upper part of the body, the head, or the neck.

Tsetse flies are confined to Africa and the shores of the Arabian Gulf ; they are found along the banks of rivers, springs, coasts of lakes, open pools, and sandy banks, especially at the foot of mountains. The places occupied by the flies are known as "fly belts."

Tsetse flies are voracious blood-suckers, exhibiting great persistency in their attacks on man and animals. They bite almost exclusively during the day. The bite is rather painful, and unless infected produces no subsequent local effects. The flies become infective about thirty-four days after feeding and remain infective for seventy to eighty days, and probably for the rest of their lives. Contrary to what is the case among horse-flies (*Tabanidæ*) and mosquitoes (*Culicidæ*), of which the female alone suck blood, in the tsetse both sexes are blood-suckers (Manson).

Besides these, certain larvæ of dipterous insects like screwworm, or of sarcophagidæ, cause myiasis in man. The larvæ are deposited in open wounds and in the ear and nasal fossæ, especially of those having offensive discharges which attract the fly. They fix and burrow in the tissues, giving rise to pain and blood poisoning which may end fatally.

Protection against Flies.—The fly should be regarded as a creature of disgusting and dangerous habits and should not be tolerated within the dwellings or on the food any more than a plague-stricken rat. Therefore every precaution should be taken to prevent fly nuisance. The following golden rules advocated by Austen are worth remembering :—

1. "It is better to prevent house flies from breeding than to permit them to breed unchecked and then

endeavour to kill the resultant broods after they have invaded houses or other habitations."

2. "No system of sanitary control can be regarded as efficient which allows house-flies to have access to materials containing, or possibly containing the germs of the disease."

The preventive measure may be considered under the two following heads :—

A. Measures against eggs, larvæ, and pupæ.

B. Measure against the adult flies.

A. *Measures against eggs, larvæ and pupæ.*—Since flies breed in filth and dung, or decayed animal or vegetable matter, measures should be taken to remove refuse, especially stable refuse, daily. Horse manure being the most favourable breeding ground, it requires careful manipulation. The best method of disposal is of course by incineration. Where this is not possible, especially in dry weather, the manure could be dried in the sun in thin and even layers, which could be collected and burnt in heaps.

It is rather difficult to control breeding of flies in ordinary domestic manure heaps. But one can reduce the number by collecting and destroying the eggs or larvæ as advocated by Capt. Marrett. The one way is to mark out the spots where flies are seen ovipositing and later to burn the cluster of eggs. The other method being to catch the larvæ in special traps during their migration to moist, cool spots suitable for pupation.

A large number of chemicals have been used and advocated to kill the maggots or eggs, but most of them proved useless. Thus for the prevention of breeding in any material *bleaching powder is absolutely useless.* A 5 p.c. solution of cresol, borax (½lb dissolved in 2 to 3 gal. of water) and powdered hellebore (*V. viride*) however are quite useful. These substances when applied in sufficient quantity prevent hatching out of adult flies.

The most difficult part of anti-fly campaign is educating the public to dispose of all household and kitchen refuse properly. No amount of screening, trapping or

poisoning will make up for careless disposal of filth and waste, which should be disposed either by burning or by dumping. The disposal of human excreta in a way that will prevent fly breeding is one of extreme difficulty. Unless fly-proof buckets are used and the night soil is removed in well covered receptacles it is impossible to prevent fly nuisance. Disposal in shallow trenches often affords an excellent breeding ground, and the larvæ

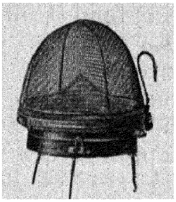


FIG. 64.—FLY TRAP.

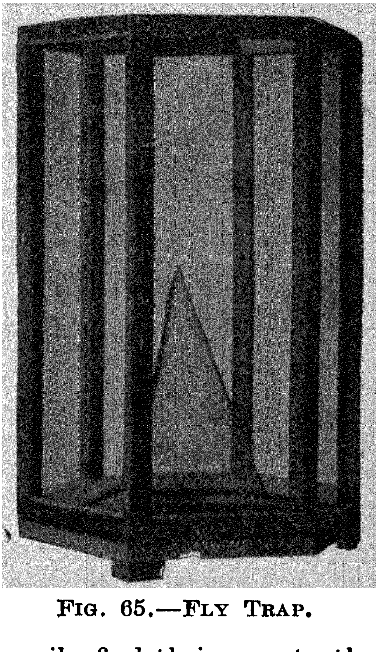


FIG. 65.—FLY TRAP.

hatched out in the excreta easily find their way to the surface. Deep trench latrines covered with fly-proof seats (See pp. 228) are more useful when properly managed. It is almost impossible to prevent breeding of flies in the latrines of private houses where the pail contents are removed only once in 24 hours. If however each person using the latrine covers up his excreta completely with earth or sand it will prevent

access of flies. Simple, though this precaution is, it is a matter of extreme difficulty to observe in practice.

B. *Measures against adult flies.*—Inspite of the precautions to prevent breeding of flies there will still be flies and to spare. These measures are therefore used for the destruction of the house flies.

Flies are killed in many ways, by adhesive fly-papers, fly traps, poisons, spraying fluids, petrol fumes and fly-killers.

The usual poisons are formalin, sodium arsenite and pyrethrum powder. A poison harmless to man is made by mixing together one dessert spoonful of commercial formalin with one pint of lime water. A little sugar, honey or treacle may be added. This mixture is put in a cup or tray and then placed in kitchens, dining rooms, etc. To be effective no other food should be accessible to flies. Sodium arsenite is a powerful poison and should be used with caution. It can be used in a small scale indoors or may be sprayed on to manure heaps. Leafy branches may be soaked with the solution and suspended in the vicinity of latrines and other places where flies congregate. Usually 15½ grs. of sodium arsenite is dissolved in 3½ oz. of water to which a little sugar or *gur* is added. In the form of spray or fume this solution is very useful in killing flies in huts, tents, buildings, etc., in the evening after the flies had settled down for the night.

Fly papers or "tangle foot" are made by heating together five parts of castor oil and 8 parts of resin powder and then spreading in thin layers on glazed paper. This is effective as long as it remains "tacky."

Fly traps are very useful in destroying adult flies and several varieties are now obtainable. A very convenient form has been devised by Col Balfour in which the flies enter through a narrow slit on the side and once inside they seldom find their way out. These are subsequently killed by fumigation. An ordinary trap consists of an outer cone or cylinder of wire gauze with an inner cone of the same material having an opening at the point and supported on short legs. The trap is baited with

stale eggs, spoiled banana or *gur* (treacle). The flies seek the bait and enter the larger cone through the opening in the lower one and are unable to find their way back. The small traps are intended for indoor use, and the large ones are placed outside on the street.

PULICIDÆ OR FLEAS

Fleas belong to the order of *Siphoneptera*, but they differ from other insects in not possessing any wings and in having a form and structure profoundly modified in consequence of their parasitic habits. They have a body flattened laterally, and have a head, thorax, and abdomen. The head is united behind to the thorax. The limbs are long and spiny, and the foot has five joints, which end in hooklike processes called claws turned in opposite directions. The anterior limbs are inserted nearly underneath the head and are more slender than the posterior ones. "The beak is composed of an exterior jointed sheath, having inside it a tube, and carrying underneath two long sharp lancets, with cutting and sawlike edges. It is with this instrument that the flea pierces the skin, and both males and females suck the blood." The amount of blood which these insects can absorb is enormous compared with their small size.

The males are distinguished from the females by being smaller and having abruptly uptilted tails formed by the end of claspers and by the large coiled-up penis. The females have no up-tilted tails but possess a curved receptaculum seminis which stands up prominently in any properly prepared specimen. The female flea lays eggs which are oval, smooth and white ; and about eight to twelve are laid on floors, dirty carpets, or dry earth. They also pass through larval and pupal stages. It takes about 2 to 4 days in summer and eleven days in winter for the larvæ to come out of the eggs. The duration may be longer in winter and may be even 21 days. The larva is an active footless maggot with scanty hairs on every segment of the body. They can be detected with some

difficulty in the dust where domestic animals sleep. When full grown they spin a cocoon usually covered with dust and dirt in which they are transformed into pupæ. In another fortnight they become perfect insects. Fleas are most common in dirty and deserted houses, and in places inhabited by people of unclean habits. Several species live on animals, but the study of rat flea is of special interest to us.

Rat Flea.—*Xenopsylla cheopis* is the common rat flea of India and of the tropics, and acts as the passive inter-

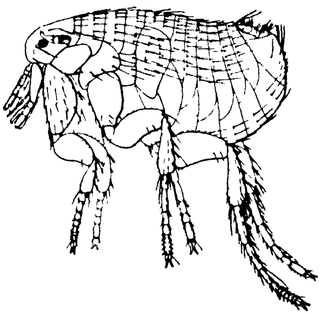


FIG. 66.—XENOPSYLLA CHEOPIS.

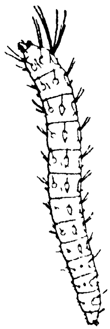


FIG. 67.—LARVA OF XENOPSYLLA CHEOPIS.

mediary carrier of *B. pestis*, not only from rat to rat, but from rat or other infected animal to man. Although it is essentially a parasite of the rat, it does not confine its attacks on rats only, and will bite man when there are no rats which it can feed on. Besides the rat fleas other species of fleas, for instance, *Ctenocephalus canis*, which bite dog, rat and man also act as carriers of plague. Fleas act not only as carriers, but also as multipliers of the germs. It has also been shown by the experiments of the Indian Plague Commission that if fleas are excluded, healthy rats will not contract the disease even if kept in contact with plague-infected rats. It resembles very much the

common flea, *Pulex irritans*, but it is smaller and light coloured, and has a number of bristles on the head.

Major Cragg has shown that three distinct species of Xenopsylla are found in India, viz.—*X. cheopis*, *X. astea*, and *X. brasiliens*. The former is most prevalent in plague-infected areas, and it is doubtful if the other two varieties play any part in the transmission of the disease. Laboratory experiments have so far confirmed Major Cragg's findings.

Sand Flea or Chigger.—*Sarcopsylla penetrans* is an excessively troublesome insect found in the West Indies and West Coast of Africa. It has now extended to the East Coast of Africa, whence it has been carried home by Indian labourers. It lives on the ground, and is abundant in dry sandy soil, particularly, near the sea shore: dirty rooms and huts, stables of cattle, etc., are the favourite haunts of these insects.

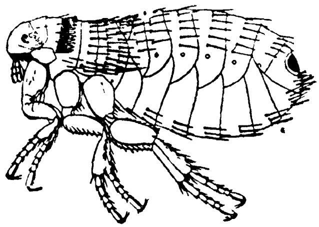


FIG. 68.
CTENOCEPHALUS CANIS.

The chigger resembles the common flea, but is a little smaller, the head being comparatively larger. It is flat, reddish brown in colour, and attacks all warm-blooded animals including birds and man. It is armed with a powerful rostrum, a prolongation of the pharynx - the epipharynx. The under surface is grooved and continuous with the wall of the pharynx. The mandibles are also grooved on the mesial surface. Being nearest the ground, the feet are the parts most commonly attacked by chiggers. The scrotum, penis, the parts round the anus, the thighs, the head and face may also be attacked.

The female, when impregnated, makes her way under the skin and becomes almost a motionless bladder through the enormous development of the ovary. During this period it sets up much irritation with inflammation and formation of pus which gives an appeararce of a pea-like elevation. When the chigger is expelled a small sore is

left behind. These insects are held responsible for causing suffering, invaliding, and indirectly death.

The common sources of fleas in a house are (*a*) want of proper cleanliness; (*b*) proximity of stables, etc., where fleas breed unchecked; and (*c*) flea carriers, viz. cats, dogs, rats, etc.

Preventive Measures.—Rats and mice must be got rid of. Dogs and cats require careful washing with soap and carbolic acid or some other coal tar preparation.

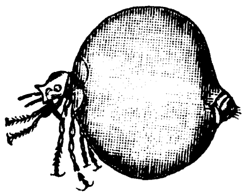


FIG. 69.

SAND FLEA; IMPREGNATED FEMALE.

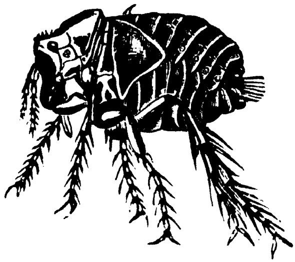


FIG. 70.

SAND FLEA.

Badly infested rooms should be thoroughly washed after sprinkling flaked naphthaline over the floor and keeping it shut for 24 hours. Petroleum, kerosene, or paraffin oil emulsion with soap will kill fleas on the floor, clothing, or on the coats of animals.

BUGS

Bed-Bug.—It is a flat, oval—on closer examination—bristly little creature, 5 mm. ($\frac{1}{4}$ of an in.) long and 3 mm. broad, of a dull amber or chestnut brown colour. The head is short and broad with a pair of prominent compound eyes and two antennæ (or "feelers"). On the lower side of the head is the apparatus with which it sucks blood. The segmented rostrum or proboscis running backwards from the front part of the head to between the bases of the first pair of legs.

It belongs to the order of Diptera and comprises an enormous number of species. In India two species,

Acanthia lectularius (*Cimex lectularius*) and *A. rotundatus*, attack man. It appears that the bed-bug was originally a parasite of birds and mammals, but although it is confined chiefly to man it has other hosts as well. It has a very wide distribution and can survive long periods—even a year—without food (Lefroy). The eggs are laid in any place to which the females can gain access—in cracks and fissures, in furniture, etc. Like a mosquito it injects an irritating fluid which causes a flow of blood to the spot on which it engorges itself.

Bed-bug is responsible for many communicable diseases. For instance some hold that kala-azar is conveyed by these pests. It has also been accused of carrying the infection of relapsing fever, leprosy, tuberculosis, etc.

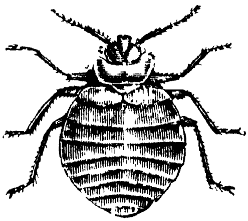


FIG. 71.
THE BED-BUG (Dorsal view).

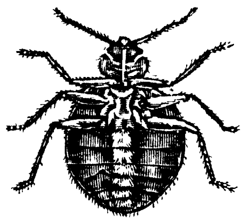


FIG. 72.
THE BED-BUG (Ventral view).

Although they cannot fly bed-bugs walk rapidly and are capable of migrating from one house to another. They are frequently introduced with luggages, boxes, etc., and are usually found in cracks and crevices of all kinds, in the wood work, walls, floors, amongst books, etc., and frequently near a bed and in the frame work of the bed itself. They are also common in chairs, railway carriages, tram cars, etc. On account of their habits bed-bugs are very troublesome to exterminate. Large wooden beds, chairs and benches furnish many cracks and crevices into which the pests force their flat bodies. Liberal application of gasoline, benzine, or kerosene oil,

emulsified with soap, is often helpful. Fumigation with hydrocyanic acid, sulphur dioxide and formaldehyde is often resorted to in railway carriages and buildings. Superheated steam may be tried. Use of boiling water where there is no possibility of damaging the articles is very effectual in destroying both eggs and the bugs.

Ammonia, olive oil, or menthol are said to allay the irritation caused by the bites. Tr. iodine and peroxide of hydrogen have also been used with good results.

Conorhinus.—This belongs to the family *Reduviidæ* and has of late attracted much attention. Thus *Triotoma* (*Conorhinus*) *megistus* is held responsible for

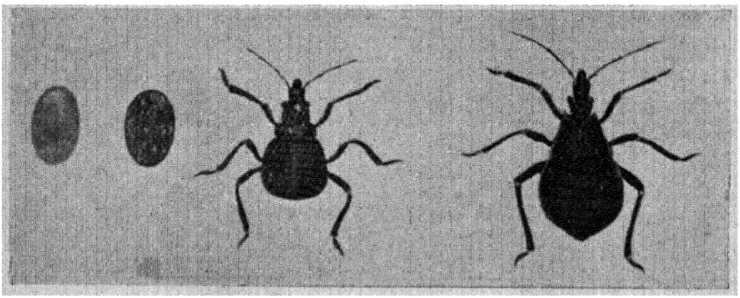


FIG. 73.—EGG AND NYMPH OF CONORHINUS.

transmitting human trypanosomiasis in some parts of Brazil where it is called "barbeiro" on account of its preference for biting the face. While in India some believe that *Conorhinus rubrofasiatus* as the likely invertebrate host of the protozoon bodies of the kala-azar. They are 1 in. or more in length, dark brown in colour. These are purely domestic insects, nocturnal in habits and are generally found near bright lights which have an attraction for them.

The exact breeding places of these bugs have not yet been discovered, but it appears that they lay eggs on trees, rat holes, cracks and crevices. The nymphs, which can not fly, crawl out of these spaces and make their

way for the search of mammalian blood and convey the infection. It takes about 5 to 6 months for the eggs to develop into the adult stage, passing through five intermediate stages, and after each stage is completed a cast off skin is left behind.

The bites are painful where it forms an inflamed and erythematous area which lasts for sometime.

TICKS

Ticks as a class of ectoparasites are most abundant in warm countries. This is ascribed to the fact that cold is unfavourable to the requirements of the egg and all the stages in early life. They form a very important class of blood-suckers and play an important part in the transmission of a disease, closely simulating the relapsing or famine fever of India. They attack all types of terrestrial vertebrates, most mammalia, the aves, some reptilia and amphibia. The ticks are sufficiently big to be seen by the naked eye, and the females are usually larger than the males. As a rule the ticks are temporary parasites ; some may live in a quasi-permanent manner, others again—as the sheep tick—may burrow beneath the skin. Ticks differ from insects in possessing four pairs of legs, and in having the head, thorax and abdomen fused into one unarticulated mass.

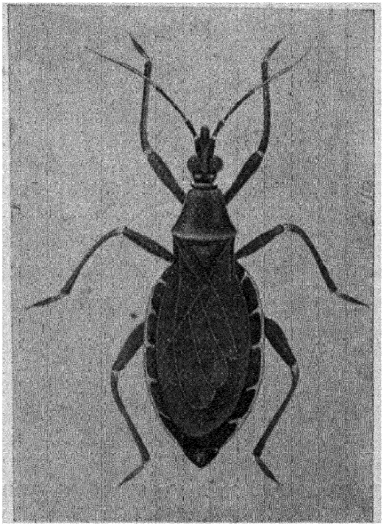


FIG. 74.—ADULT CONORHINUS.

The female lays eggs in large numbers on the ground and then dwindles up and dies within a few days. The

eggs are small grains of a yellowish colour, and in two or three weeks' time they are hatched, giving rise to larvæ which look like minute moving grains of sand, and are characterised by having six legs, no stigma, and no sexual organ. After a short period of rest the larvæ seek food: they swarm up to the tips of the blades of grass and await in clusters their warm-blooded host. It then becomes gorged with the blood of the host and passes through its first moult and emerges through the larva skin as a nymph. The nymph presents four pairs of legs, but still no sexual organs. Like the larva, it moves about until it attaches itself to some warm-blooded host

FIG. 75.
TICK (Ventral Aspect).

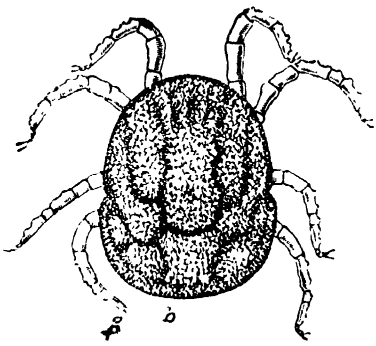


FIG. 76.
TICK (Dorsal Aspect).

and then drops off to moult again, when it becomes sexually mature. Having thus reached maturity the sexes unite. After fertilization the male dies while the female proceeds to feed on the blood of her host for the development of her ova. On account of the difficulty of finding a suitable host ticks at all stages are endowed with a phenomenal capacity for fasting. In fact they have been found alive after a fast of four years' duration (Manson).

The ticks are nocturnal in their habits, like bed bugs, and live in huts, cracks, and crevices in the walls, floors,

or in thatch or reeds, of which the roof and walls are composed. They are frequently carried in mats or bedding, or in porters' loads which have been stored in rest huts at nights.

Breeding of ticks in the laboratory is not so easy. A complete knowledge of their bionomics is necessary before any attempt could be made, since success depends entirely on a thorough understanding of the life history and the habits in the early stages. Thus, the whole life cycle from the egg to sexually mature adult stage may be completed in one species of host, or the succeeding stages may feed on other species.

The fact that the tick remains fixed on to the skin of an animal does not necessarily mean that it is feeding on the host. While some species remain fixed on to the skin of animals others drop off after a feed of blood. Copulation usually takes place on the skin of the host.

The ticks which feed on infected persons do not themselves become infective, as the infection is transmitted to the progeny, and therefore, if a tick feeds on an infected person, it may be some time before the progeny of these ticks can infect a susceptible person.

The species of ticks which are of special interest are *Ornithodoros moubata* and *Argas persicus*. The mischief caused by the ticks is not confined only to man. The havoc caused by them is best seen in the cattle. They are the transmitters of several species of piroplasmata and spirochæta. The various kinds of relapsing fever due to spirochætes may be transmitted from man to man by means of these arthropods.

The relapsing fever of Africa and America, the tick fever of Miana (Persia), the spotted fever of the Rocky Mountains, the Japanese river fever, etc., are all transmitted through the agency of ticks. How far they are responsible for the propagation of typhus and typhus like fever is left for future workers to decide.

Destruction of ticks is a difficult matter. Mud floors, reed and thatched walls and roofs cannot be thoroughly cleaned; while travelling huts should be avoided.

O. moubata cannot climb up a smooth wall. Bedding should not be placed on the floors, and should always be carried in a tin box. There is little risk in the day time or when the rooms are lighted.

Ticks in animals are controlled by dipping in a solution of sodium carbonate 24 lbs ; acid arsenious 8 lbs ; tar 2 gals ; water q.s. to 500 gals. Crude petroleum has been used largely. The cattle may be treated by applying the above mixture by means of cloth or spray.

Lice

Lice are small wingless insects living entirely on mammalian blood. The whole life cycle of the louse is bound up with that of the host. Three varieties of pediculus are parasitic on man, viz., (*a*) *Pediculus capitis*, or head louse ; (*b*) *Pediculus humanus corporis*, or body louse ; and (*c*) *Phthirius pubis*, or crab or pubic louse. It is possible that other mammalian lice may temporarily infest man.

The head and body lice resemble each other so much that they cannot be distinguished by any single character. On the other hand the typical ones are quite distinct. The head is conical with a constriction where it joins the thorax, and provided with a proboscis, a pair of jointed antennæ and a compound lateral eye. The head louse is generally darker, smaller and more bristly. Its antennæ are thicker with deeply cut abdominal division. The body louse is paler, larger, with slender antennæ, and the notch of the abdomen merely undulated. In each of the three varieties there are three pairs of jointed legs terminating in claws. The surface of the limbs, thorax and abdomen is provided with scattered hairs. In length they vary from 1 mm. to 4 mm.

The Crab Louse.—This is easily distinguished by the small size, square body, blunt and trunkated head, relatively large and strongly developed legs, prominent breathing apertures, and extreme inertness. They are generally found in the pubic and perineal hairs, and occasionally among the eye lashes. In fact they are found

on any part of the body where the hair is suitable, excepting the head where it finds some difficulty in holding.

The female lays up to 300 eggs, from 8-12 a day, usually deposited either on hair, or on cloth, and are $\frac{1}{25}$ in. long and $\frac{1}{60}$ in. broad. At one end of the egg is the operculum which opens and may be removed at the hatching of the larva. Between the egg and adult stage a

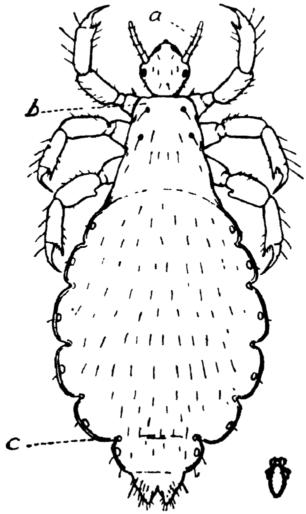


FIG. 77.—THE BODY LOUSE.
(Female)

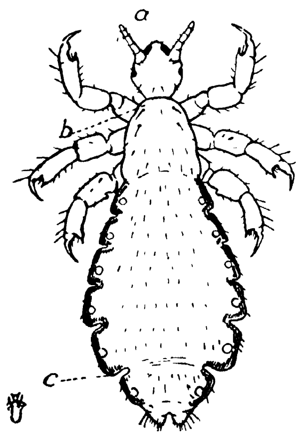


FIG. 78.—THE HEAD LOUSE.
(Female)

a, antenna ; *b*, width of body behind neck ; *c*, depth of the clefts between the segments.

louse moults its skin three times, generally at an interval of 2 to 4 days. The whole process of development from the laying of the eggs to the appearance of the adult louse may take about a fortnight.

A louse generally lives about two months provided it has facilities for feeding, etc.

Dissemination of Lice.—Contact is the determining condition of their dissemination. Lice neither arise from filth and dirt, nor spontaneously. Dirty habits favour the increase of lice if once they get a foothold. Head

lice pass from unclean servants to the child, or in school from one scholar to the other. They may be spread by brushes, hats kept in close proximity, clothing of lousy subjects, and infested bed occupied by a clean person. They may be blown about by high wind, and heavily infested persons often drop lice which may cling to benches, floors, carpets, etc. Dogs sometimes carry human lice from person to person. Head lice are common on women and children, body and crab lice on men. All three varieties may exist on one person.

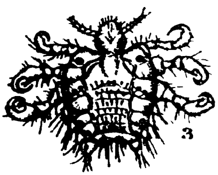


FIG. 79.
THE CRAB LOUSE.

Lice have been condemned as carriers of many diseases, chiefly typhus, relapsing fever and trench fever. Many skin diseases are initiated by lice, *e.g.*, impetigo.

Prevention of Lousiness.—

1. Regular washing of under clothing and bed linen. These measures alone will prevent lice to thrive even if casual infestation occur.

2. Since most infestations are from personal cantact, one should avoid coming in contact with a verminous person. Do not introduce lice into the house.

3. Those coming in contact with infested persons, *e.g.* nurses, should wear linen overalls. Undergarments may with advantage be impregnated with some insecticide.

The following treatment is necessary for those who have already got infested.—

1. A hot bath with a complete change of clothing followed by thorough disinfection of all garments.

2. The hairs should be cut short or better shaved. This is often sufficient when shaving is not possible as with girls or women. Some insecticide may be first applied, *e.g.* ammoniated mercury ointment 5 p.c. per ounce once a day, or calomel pomade (1 in 20 of vaseline) followed by brushing with a fine toothed metallic comb previously warmed.

3. *Disinfection of clothing and bedding.*—This may be done by (*a*) *dry heat* which is the simplest and least

expensive method. A temperature of 130° F. or 55° C. for twenty minutes is fatal to both adults and eggs. When used as dry heat the clothes should be loose and not tightly packed; (*b*) *steam*: this is very useful when used in any steam disinfectors; (*c*) *hot water*, and (*d*) *naphthalene*; a small handful of flaked naphthalene scattered evenly between the blankets is often very effective.

The clothes should be removed on a clean floor and not on a carpet or other articles where the pest or its eggs can lodge.

4. *Insecticides*.—Kerosene or petrol are very effective for nits, especially when mixed with some essential oil, *e.g.* oil of sassafras, oil of eucalyptus, cedar wood oil, tar oil, etc. Lysol, cresol, and naphthalene are also good insecticides.

CHAPTER XVIII

ANIMAL PARASITES

ALTHOUGH parasites belong both to the animal and vegetable kingdoms, only the animal parasites will be discussed here. Of the animal parasites which affect human beings some are external and some internal. The former belong to the classes of insects (which see) and the various acari, the latter include the worms and a variety of protozoa.

Parasitic animals are those which in order to obtain their nourishment, live within or upon another living organism, known as their host. True parasites nourish themselves on the living material, *e.g.*, blood or lymph of their host ; saprophytic parasites derive their nutriment from dead material. Many parasites are pathogenic, and although some saprophytes do not harm their hosts, it is doubtful if the animal parasites are ever " Symbiotic " *i.e.*, whether any are beneficial to their host.

Some parasites—*Trichina spiralis* are found in different species of animals, whilst others are limited to a single species, *e.g.*, *Tænia solium* and *Oxyuris vermicularis* are parasitic only in man. The anatomical situation of a parasite is known as its habitat, and they are designated *ectozoa* or *entozoa* according as they live upon or within their host.

The mode of reproduction within the body of the host is both interesting and varied. Some—the protozoa—produce successive generations within the host ; others, *e.g.*, the worms when within the host merely attain sexual maturity, and give origin to a second generation which however does not attain sexual maturity in the same host. In other instances two specifically different hosts are necessary for completion of the life-cycle of the para-

site, which is immature in the one and sexually mature in the other. In the latter instance a change or alteration of the host is necessary for the developmental cycle of the parasite, and the animal harbouring the sexually mature parasite is the *definitive host*, that harbouring the immature parasite is the *intermediate host.*

There are various ways in which man may be infected. The most common mode being the ingestion of eggs or immature forms of parasites together with water or other fresh food. By the ingestion of eggs man is infected with *Cysticercus cellulosæ*, *Ascaris lumbricoides*, *Oxyuris vermicularis,* etc. ; by the ingestion of immature species man is infected with *Ankylostomum duodenale,* and *Trematodes.* Again, infection may be from the ingestion of the immature parasite in an intermediate host. It is in this way man becomes infected with adult *Cestodes* and *Trichina spiralis.* Finally, parasites may be transmitted by the direct agency of the second host, *e.g.*, malaria.

Effects of Parasites.—The animal parasites may cause disease in a variety of ways :—

1. By Mechanical injury.
2. By producing inflammatory reaction in the tissues.
3. By withdrawal of nutrient material.
4. By removal of blood.
5. By production of toxins.

Cestoda

The members of this class which are indigenous in man, are long, flat and tape-like worms inhabiting in their adult form the intestinal canal. These are commonly known as "tape-worms." Four varieties are parasitic in man, and three of these *Tænia solium*, *T. saginata* and *Bothriocephalus latus* are found in the intestine, while the fourth *Tænia echinococcus* is found in the cystic or intermediate stage in the liver or other parts. The worm consists of minute head and neck with a longer or shorter row of attached segments. The head is about 1 mm. to 2 mm.

broad, provided with suckers by which these worms fix themselves to the intestinal wall. Behind the head is a long narrow neck followed by rows of segments or proglottides of which the worm almost entirely consists. The segments while remaining attached to one another constitute a "strobilus," The whole tape-worm is therefore often regarded, not as a single animal, but as a polymorphic colony. These segments are small and imper-

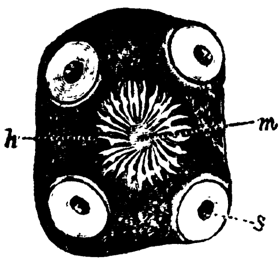


FIG. 80.

HEAD OF TÆNIA SOLIUM FRONT VIEW.

h, hooklets ; *s*, suckers ; *m*, summit of rostellum.

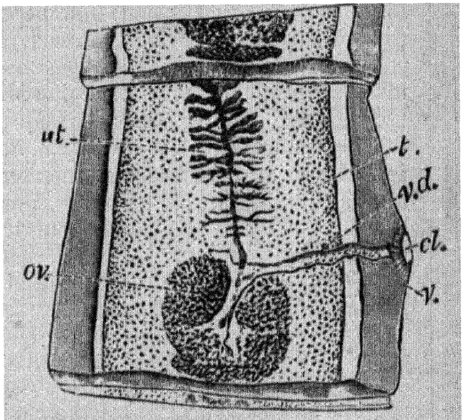


FIG. 81.

ONE OF THE MIDDLE SEGMENTS FROM A TÆNIA SAGINATA.

t, testes ; *v.d.*, vasa deferentia ; *ov.*, ovary *ut.*, uterus ; *v*, vagina ; *cl.*, genital pore.

fectly developed and less defined near the neck, but grow larger and more defined towards the end. The central and the more posterior ones are well marked with lines of demarcation, and present well developed generative organs. Since they live on the nutriment directly derived from their hosts these worms are devoid of any digestive organs. But possess a complete water-vascular system which take the form of longitudinal tubes running down each side.

The life-history of these worms is interesting. The mature proglottides are dislodged from the parent worm and the ova are set free which retain their vitality for sometime. If at this stage these ova are eaten by some animal capable of acting as an "intermediate host" they continue their development until the shells are dissolved off in the alimentary canal and an embryo with six hooklets is set free. These hooklets enable the embryo to penetrate the wall of the alimentary tract and by way of the blood-stream or some other channel, reach some dis-

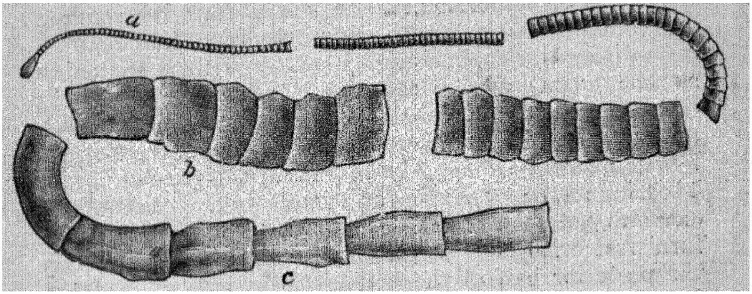


FIG. 82.—PORTIONS OF A TÆNIA SAGINATA.
a, head, neck and commencing segmentation ; *b*, central ; *c*, terminal proglottides.

tant part. The hooklets eventually disappear and a cavity appears and a fully formed head is formed from the walls of this cavity which becomes enclosed in a fibrinous capsule supplied by the surrounding tissues. During the cystic or intermediate stage the parasite is known as *cysticercus* and may live for many months. If some tissue containing a living cysticercus is swallowed by an animal capable of acting as the "definitive host" the capsule is dissolved off and the *scolex* or the head is set free. After attaching itself by its suckers and hooks to the intestinal mucous membrane it buds off successive proglottides from its distal extremity. It takes about two months between the swallowing of the cysticercus and the passage of the first proglottides from the rectum.

NEMATODA

All round worms occurring as parasites in man belong to the order of Nematoda. They have very slender bodies without segments or appendages and are usually bisexual with a well developed mouth and alimentary tract at one end and an anus at the other. The males are usually smaller than the females, some are quite harmless, while the others are more dangerous. The following are some of the important worms parasitic in man :

1. **Ascaris lumbricoides.**—In general form it resembles the common earth worm, being cylindrical and pointed at both ends, of pinkish-grey colour with a glistening surface when alive. They are the most frequent in occurrence of all the parasites and is especially so in children between the ages of three and five years. The adult female measures about 7 to 14 inches, and the male from 4 to 8 inches, being as thick as a goose quill. The cephalic extremity of both male and female has three oval papillæ furnished with fine teeth. The sexual organs occupy the posterior half of the body, the organs being at the junction of the middle and anterior third of the body. The female lays eggs in enormous numbers, and have a thick shell, outside which there is often a clear, irregular, albuminous sheath. When swallowed these eggs find their way into the upper part of the small intestine where they develop into the adult form in the course of a month.

The eggs are present in great numbers in the fæces, and infection occurs without there being any intermediate host, by means of contaminated drinking water or food.

Ascaris lumbricoides is found in all parts of the world. They occur in large numbers, in dozens and sometimes in hundreds. The effects are due to irritation giving rise to colicky pains, and in children often convulsion and other nervous symptoms, possibly due to toxins which the worms naturally possess or excrete, as a product of their metabolism. The worms are migratory in their habits.

They often wander into the stomach (whence they may be vomitted out). They have been found in the bile-duct, pharynx, larynx, trachea and even lungs, giving rise to different symptoms. In a few instances they may be matted together in the intestine and cause intestinal obstruction.

2. **Oxyuris vermicularis.**—These are commonly called "Thread Worms" and are found mainly in children. They inhabit the colon especially the cæcum where they may exist in enormous numbers. As the females become pregnant they pass into the rectum and lay immense number of eggs. The female is $\frac{1}{3}$ to $\frac{1}{2}$ inch in length and the male half that size. They develop from ova in about three weeks, these ova do not develop unless passed through the stomach. They must therefore be passed per anum, and the host re-infected by the mouth before a new generation can develop. Water and food contaminated with the ova are the common sources of infection. These worms crawl out of the anus and give rise to much local irritation and often leads to many different types of symptoms, *e.g.*, enuresis, cough, restlessness, convulsion, etc. They may enter the vagina in females and cause vulvo-vaginitis, pruritus and leucorrhœa. The itching leads to scratching and thus the eggs are often deposited under the finger nails. In careless and uncleanly persons the possibility of an auto-re-infection should be kept in view and steps taken to prevent the same. The nails should be short and kept clean and dipped frequently in quassia infusion. The children should be isolated until cure is effected.

3. **Filaria.**—The filariæ inhabit chiefly the blood vessels, lymphatics, connective tissues, and serous cavities of their host. Their mode of development is unknown, although it has been clearly established that they complete their life cycle through parasitism in two sets of host. The host in which the filaria reaches maturity and gives birth to its offspring is known as definitive host, the other being known as intermediary or secondary host. In *Filaria bancrofti* we have an example of double parasitism, man and certain species of culex.

Filariæ are long slender thread-like worms with a curved or spiral tail. They are mostly parasitic in man, thus *Filaria oculi* is found in the tissues of the eye, *Filaria loa* in the subcutaneous tissue. Of greater interest is a group of filaria known as *Filaria sanguinis hominis*, because the embryos are found in the blood, of this again the *Filaria sanguinis hominis nocturna* is the best-known member, the adult of which is generally known as *Filaria bancrofti*. The female has the appearance of a white thread about 3½ inches long. The male is very much smaller and less frequently found. In both sexes the posterior end is blunt and the head slightly bulbous with a central unprotected mouth. The generative organ is close to the head in females. The embryos found in the blood are about one-nineteenth of an inch long and in breadth equal to the diameter of a red-blood cell. The parasite is provided with a fine sheath which it does not completely fill and in which it can move backwards and forwards.

The nocturnal filaria is found only at night, or if the host either by habit, necessity or choice, a day sleeper, during the day, thus showing that there is some condition of the body during quietude that is conducive to the appearance of the filaria in the blood. At mid-night they appear in greatest numbers, and Manson has estimated that there may be as many as 50,000,000 present in the blood of a single individual at that time. They gradually diminish in number, and by six or seven in the morning entirely disappear.

The embryos of filaria sanguinis hominis are produced by the female in great numbers, they are so small that they pass readily through the capillaries. During the night some of the parasites may be removed by mosquitoes. It is probable that after filling itself with the blood of an infected man during sleep, the mosquito seeks stagnant water, dies, and the larvæ are set free. In this way infection takes place through drinking-water.

It has been shown that the filaria once in the stomach of the mosquito sheds its envelop, pierces the wall of the stomach, and lodges in the thoracic viscera where

the embryo undergoes further development during two weeks, then finds its way into the proboscis to be discharged into the blood of the human host. Once introduced into the human body it finds its way into the lymphatics where it matures and brings forth young, and in due course new generation of larval filariæ are poured into the lymph which may again infect the blood by passing through the lymph ducts, into the thoracic duct and general circulation. It is evident therefore that like the malaria parasite the filaria is introduced into its human definitive host by mosquito bite.

Effects.—The most common effect observed is periodical attacks of lymphangitis with fever generally known as elephantoid fever. These attacks are accompanied by swelling of the affected limb, to be followed later by more or less permanent œdema of a greater or lesser degree. Several such attacks are followed by an overgrowth of the skin and subcutaneous tissue giving rise to *elephantiasis arabum.* Once the case is developed few filariæ are found in the blood. The absence of embryos is due to the blocking of the channels through which they would reach the blood-stream. In some cases the lymphatics in the abdomen, scrotum, or the kidneys become varicose and filled with chyle giving rise to chylous ascites, lymph scrotum or chyluria.

Prophylaxis.—To prevent filarial disease one must protect himself from mosquito bite. Wells, tanks and stagnant pools must not be allowed in the vicinity of dwelling house.

The subjects of filarial disease should be regarded as dangerous.

4. Ankylostomum Duodenale

Hook-worm is a common parasite of the intestine and causes a disease variously named. Thus in Columbia it is known as *tun-tun* ; in Europe, miners anæmia or tunnel disease ; in Egypt, Egyptian or tropical chlorosis. This disease was first described in 1618, but the cause was then unknown. The first hook-worm was discovered in 1782 and 1789. In 1883 Dubini described the worm

FIG. 83.
A. DUODENALE FEMALE.

FIG. 84.
A. DUODENALE MALE.

and since then the ankylostomum has been found so widely diffused that it may be said to occur in all tropical and sub-tropical regions of Asia and America. It is also present in South of Europe, and is very prevalent in India. Latest observations made in different parts of Bengal show an enormous prevalence of this affection. Roughly about 36 to 40 million people in Bengal are infected with larger or smaller number of the parasite. In Egypt it is found present nearly at every post-mortem examination.

Two distinct varieties of the worm are recognised. The *Ankylostomum duodenale* or the old form, and the *Uncinaria americana* or *Necator americanus*, the New World species. Both types are common in Bengal. Hook-worm is almost cylindrical, the males 6 to 10 mm. ($\frac{1}{3}$ inch) and the females 8 to 18 mm. ($\frac{1}{2}$ inch) long. Its body is thread-like with a conical-shaped head, and a large bell-shaped mouth surrounded by a horny capsule with four vertically situated hook-like teeth and two smaller vertical teeth on the dorsal side

by which the worm fixes itself to the mucous membrane. Towards the tail end of the male worm there is an umbrella-like expansion or copulatory bursa. The eggs are found in muddy water, or in warm moist earth where they liberate the embryos. These develop into larvæ which soon enter the dormant state remaining quiescent for an indefinite period until they are taken into the human stomach.

Man is probably the only host of this worm, although the same species is said to be parasitic in certain monkeys. The parasite inhabits the duodenum and upper parts of the small intestine.

Mode of Infection.—Hook-worm disease is pre-eminently a rural disease, being limited to imported cases in

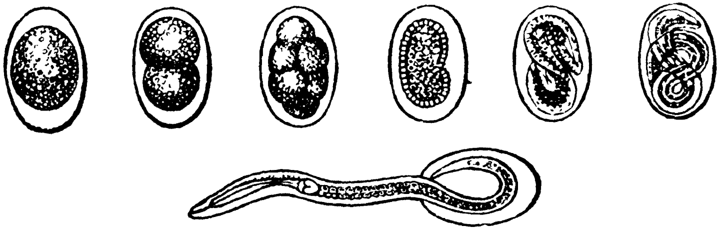


FIG. 85.—EGGS OF HOOK-WORM WITH EMBRYO ESCAPING FROM ITS EGGSHELL.

large cities. Two modes of infection have been proved experimentally, *viz.*,—through the mouth directly, and through the mouth indirectly by way of the skin. Direct mouth infection is of minor importance in the dissemination of the disease. The eggs cannot hatch in the intestinal canal for lack of oxygen and perhaps for other reasons. Indeed Looss and others have shown that the young worms cannot infect until they have reached certain stage (encysted stage) of their life, which requires at least 4 or 5 days after they are hatched out (which requires 18 hours or more after the fæces have been expelled). The number of eggs passed with each stool of a badly infected person has been estimated

to be over 4,000,000. During the larval stage they attempt to get into the moist earth or wood, and have a strong tendency to migrate or crawl upon near objects, such as leaves, stalks or fruits of such vegetables that are eaten raw, and no ordinary washing could be expected to remove all the larvæ. At this stage they are very resistant to germicides, heat and cold, and will live a long time if moisture and oxygen be available. They possess a wonderful ability to penetrate the skin to which they can attach themselves even after a very brief contact. The skin of the foot in persons going about without any protection is commonly the site for the entrance, although ankles, hands and arms may also be attacked. According to Looss this is the most usual mode of infection, and he claims to have been infected in this manner, while making some experiments with cultures of ankylostomum larvæ. Once having fixed on to the skin the larvæ burrow through it causing a dermatitis which is variously known as "ground itch," "toe itch" or "ground sore." After reaching the subcutaneous tissue they enter the capillaries and are carried into the heart, from the heart they pass into the lungs and enter the bronchial tubes through the capillaries. They are then carried into the mouth and are either coughed out or swallowed. In the stomach they remain uninjured by the gastric juice and pass into the intestine where the larvæ develop into the adult form, but before this final stage there is an intermediate existence when they fix themselves to the mucous lining and bore into it, presumably for the purpose of making a nest to lay their eggs. It is clear therefore that the real source of hook-worm infection is always the fæces of infected persons and that the only practical mode of infection is by the skin.

Symptoms.—There is probably no disease in which the symptoms are so variable as in hook-worm disease. It is certain that every worm that enters the body comes from without, and that a patient cannot directly infect himself since the eggs cannot hatch in the intestinal canal. The symptoms are mainly due to loss of blood and the effects of a toxin which may have some destructive action

on the blood. The most common symptoms are those of indigestion and dyspepsia. Lack of energy, apathy and anæmia are common during the early days of the attack, hence the disease is commonly known as "lazy disease." Except in severe and acute cases or when the condition is of long standing the symptoms are very indefinite In well marked cases severe anæmia and dropsy are characteristic. Palpitation, shortness of breath and general weakness are often noticed with indefinite pains all over the body and joints. The taste may often become perverted and some patients show a craving for eating earth, mud and lime.

Prophylaxis.—Theoretically prevention of hook-worm disease should be an easy matter, since its cause is known and all the characteristics of the parasite are understood. But in practice it is one of the most difficult diseases to handle owing to its wide extent, enormous reproductive power of the worm, rapid development of the ova in the infecting stage, and the fact that infection is the direct result of careless and filthy habits. The problem of prophylaxis involves the following :

1. Extermination of the mature worms in the bodies of human beings, thus stopping the danger of infection.
2. Preventing the growth and existence of the larvæ.
3. Preventing the infection by larvæ that have developed notwithstanding the above efforts.

1. *Extermination of the Mature Worms.*—The first step in the prevention of the disease is to stop it in those already affected. Accurate diagnosis, careful treatment on modern lines followed by examination of the fæces will to a great extent reduce the supply of ova and the possibility of fresh infection. But there still remains another source of danger through "carriers" who present no special symptoms, or symptoms so mild as to pass unnoticed, but who harbour from a few to a couple of hundred worms which lay eggs in large numbers all the time. These carriers are all the more dangerous and should be isolated and properly treated. Periodical examination of all persons living in infected localities and under conditions favourable to the existence of larvæ

is necessary. In mills, factories, plantations, etc., all workers should be similarly examined, and any one suffering from dyspepsia or anæmia more carefully examined, and if any ova of ankylostomes are found in the fæces they should be segregated and adequately dealt with.

2. *Prevention of Soil Infection.*—The next essential is the prevention of soil infection. Ankylostomiasis is pre-eminently a filth disease and the only means of infecting the soil is by evacuation of the bowels where the ova in the fæces may later develop. Any measure to be useful and effective must be directed towards the prevention of this source of infection. The practice of the people to pass excreta in or about the dwellings, open land or on the banks of rivers and tanks should be rigidly interdicted—a most difficult task which the sanitarian will have to face. This and the resistance of the larvæ along with favourable conditions of temperature and moisture explain the danger of the disease. The larvæ are scattered by rains and all traces of the fæces are lost, but the porous moist earth becomes permeated with the larvæ in the encysted and infectious stage. Sufferers and the public should be impressed with the fact that the fouling of the soil is the cause of the trouble, and the dangers of soil pollution and the necessity of avoiding such practice should be forcibly brought home to them. For the prevention of soil pollution, installation of sanitary latrines is essential. The construction and use of such privies and the safe disposal of night soil should be carefully explained and their advantages clearly shown. Particular attention should be paid in providing easily accessible privy accommodation, especially where a large number of men congregate and work, *e.g.*, in mills, factories, in mining districts and along the high ways of traffic. Septic tank latrines or "aqua" privies are ideal arrangements. These latrines must be easily accessible so that neither indolence nor weakness will lead to the use of less secure areas. They must be inaccessible to animals and screened against flies and other insects from transporting material from them. While devising privies and sanitary accommodations the habits and prejudices

of the people they are intended to benefit must be taken into account.

The larvæ are killed in deep or running water, but can live for long periods in shallow water along the edges of streams—just the place used by people for washing and other purposes. Moist earth especially if sandy so as to retain moisture, or shaded by vegetation offers ideal conditions for the life of larvæ and should be dealt with properly.

3. *Prevention of Infection.*—Considering the fact that infection and dissemination of the disease are mainly due to the ignorance and uncleanly habits of the people, it is essential that steps should be taken to educate the public, without which the problem of prevention can never be solved. Law is not the instrument best fitted to compel a man to be clean and live up to the rules of hygiene : to be effective, the people must appreciate the philosophy and spirit that originate such laws and measures. They should not eat muddy fruit or vegetables, and should not drink muddy water, or water from muddy receptacles. Earth-eating should be prohibited and all water for drinking purposes should be boiled. Every one living in hook-worm areas should be taught the essential facts about the worm and their effects. Specimens, charts, diagrams, illustrations of patients before and after treatment with descriptions should be exhibited, popular lectures given and pamphlets printed in the vernacular of the place freely distributed. Cultivators and others working in mills, factories, plantations, etc., where the disease prevails should be told of the danger of going about barefoot. In rural areas where people work on the fields the use of shoes by the cultivators is unknown, and during the rainy season when the fields and roads are sloppy or partly inundated, villagers hardly ever have recourse to the use of boots and shoes which they consider more than a luxury. Be that as it may, the utility of using boots and shoes, and in their absence wooden sandals (*Kharrams*), as a means of reducing and preventing infection should be impressed on the people.

CHAPTER XIX

RESTRAINT OF INFECTION

HAVING discussed in the preceding chapter the nature of the different infective agents and the various means by which they are carried into the human system one will now appreciate the importance of the measures calculated to prevent or restrain the spread of different infectious diseases. Modern research has thrown considerable light on what formerly was full of darkness, and although much remains to be done, yet whatever progress has been made has exposed many defects and brought many changes in the older methods of prevention. Thus, our knowledge with regard to the transmission of malaria and plague has directed our attention to the protection against mosquitoes and destruction of rats. Similarly our knowledge regarding the food-supply as a source of danger has led to the introduction of inspection of animals before slaughtering, model dairies, cow-sheds, slaughter house, etc.

In order to fight with the different infectious diseases effectively it is of primary importance to be acquainted with the habits of the different organisms, and as filth, foul air, bad water and unhealthy surroundings are essential for their existence, cleanliness is the weapon to be used against them.

Before discussing the special preventive measures for individual infectious diseases it is necessary that the student should understand the general principles of the following:

1. *Notification.*—This requires every practitioner who diagnoses a case of infectious disease to notify to the Health Officer or Civil Surgeon of the district to enable him to take necessary precautions at once.

2. *Isolation* of the infected person.

3. In certain more dangerous diseases, like plague, small-pox, etc., *quarantine* may be imposed on persons who have been in contact with the patient.

4. Protective inoculation or production of *artificial immunity*.

5. *Disinfection*.

1. Notification

By "notification" is meant the immediate intimation of the outbreak of every case of infectious disease to the Health Officer or sanitary authorities.

Notification of all infectious diseases to the sanitary authorities is only a means to an end, as it enables the medical officer of health to take immediate measures for preventing the further spread of the disease by isolation and disinfection, and other necessary action. According to Whitelegge the advantages of compulsory notification are :—

(i) Early and complete knowledge of all cases of notifiable disease, and thus of its whole prevalence and distribution in the district or town.

(ii) Power to exercise such supervision, as may be necessary, over every case during its whole course, and to enforce due observance of the provisions of the Public Health Act as regards isolation and disinfection. This is of great importance in the case of outbreaks of diphtheria, scarlet or typhoid fever in dairies, schools, etc.

(iii) Opportunity of removal to hospital of every suitable case ; other preventive measures, as vaccination in cases of small-pox, can be offered.

(iv) Opportunity of investigating the sanitary condition of all households where cases of enteric fever or diphtheria, or other notifiable disease may occur.

(v) Power to control the spread of infection through schools or other centres by excluding members of infected households.

(vi) Means of detecting at once any suspicious grouping of cases around schools, and examining milk-supplies, water supplies, and other common foci.

Immediate notification enables the authorities not only to isolate the sufferers and thus prevent them from acting as centres for disseminating the disease, but also to find out the real and original source of the same. With the poor isolation in a hospital not only ensures proper treatment but also better comforts.

There is no Notifiable Disease Act in India. Only a limited number of municipalities and the presidency towns enjoin medical practitioners to report infectious diseases, particularly cholera, small-pox, plague, typhoid fever, and diphtheria, occurring in private or public houses. But this has proved to be of little value. It is important also that the sanitary authorities should be in a position to adopt immediate steps for the seclusion of patients at home, and for their removal with due care to special isolation hospitals.

2. Isolation

Isolation is separation of the sick, in case of any infectious disease, from the rest of the household to render transmission of contagion from the sick to the healthy impossible. For persons in easy circumstances isolation can be satisfactorily carried out at home. But for the poor who live in insanitary *bustees* or quarters, with insufficient accommodation, and in schools, workshops, etc., the sick should always be removed to the nearest isolation hospital as soon as the infective nature of the disease is recognised.

Home or Private Isolation.—For the isolation of persons suffering from infectious diseases in their own houses the following points should be observed :

(i) Whenever practicable the number of rooms should be two, on the top floor, or in a detached portion of the building.

(ii) All furniture, clothes, etc., not required for the patient should be removed beforehand.

(iii) The doors should either be kept closed, or a screen soaked in some disinfectant solution, like 1 in 20 carbolic acid, should be hung over them. This not only prevents

germs from being carried by wind, but also acts as a danger signal to the visitors.

(iv) The windows should be kept open for free circulation of air.

(v) A fire may preferably be kept up for destroying waste materials like rags contaminated with discharges, and also to promote ventilation.

(vi) No one excepting those who are in actual charge of the patient should be allowed in the room. The nurses or attendants should take good care to wash their hands with some antiseptic lotion and disinfect their changed clothes. The dress of the attendants should be of some non-absorbent materials which can readily be washed. Fresh dresses for nurses and attendants should be kept in the adjoining room.

(vii) No clothing or utensil should be taken out of the sick room without previous disinfection.

(viii) Excreta and food remains should be removed in vessels containing some strong antiseptic and then buried or burnt.

(ix) Neither visitors nor any member of the house should enter the room, but if necessary should speak through the screen or window.

(x) When the danger of infection is over, the patient should be washed and bathed thoroughly with soap and water, and have a complete change of clothes before being allowed to mix with other people.

(xi) Flies and mosquitoes must be absolutely excluded by screens, those already present in the room must be destroyed.

It need hardly be said that the above precautions are very difficult to be carried out thoroughly in a private house, even if the patient and the family give the most willing assistance. It is better whenever possible to remove the patient to a hospital, where he will be less dangerous to his own people and his neighbours. It should be remembered that a very imperfect and incomplete isolation is better than none, and may serve a useful purpose in checking the spread of infectious diseases.

Isolation Hospital.—In every town it is necessary that provision should be made for the accommodation and treatment of infectious cases. This is best carried out in an isolation hospital. The essential features of an isolation hospital are that the site should be dry, healthy, and well drained, and although well away from congested quarters yet not far enough to cause inconvenience. Separate wards should be provided for the admission and treatment of different infectious diseases. In India this is only done for cases of small-pox, cholera, and plague. A floor space of 144 sq. ft. should be allotted for each patient, and each patient should get about 6000 c. ft. of fresh air per hour. One bed for every 1000 of the population is to be calculated upon. There should be a special observation ward where all suspected cases should be kept.

Proper arrangements should be made for removal of excreta and disinfection of soiled clothes, bedding, etc. It is better to keep separate ambulances for the removal of the sick, but whenever ordinary carriages or *palanquins* are used, care must be taken to disinfect them thoroughly.

Ambulances.—Ambulances may be either wheeled or carried on the shoulders as *doolies*. When wheeled, they had better be rubber tyred, and may be drawn by horse, bullock, or man ; but the motor ambulances, as used in Calcutta, appear to be the best of all. Ambulances should be kept in all police stations and public places, and should be thoroughly disinfected after each use.

Segregation of the inmates of infected houses in special camps is sometimes adopted as a precautionary measure for early detection of any case occuring amongst them. During the first outbreak of plague this method was adopted by the Government of India.

Investigation of Infectious Disease.—According to Whitelegge enquiries on the following points should always be made in investigating a case of notifiable disease :—

1. *Patient.*—Address, name, sex, age, date of onset, date of rash, present and past isolation, probable source

of infection, recent contact with infected persons or things.

2. *Household* (*including patient*).—Sex and age of each inmate, susceptibility (as shown by history as to previous attack), date of previous attack (if any), occupation, place of work or school and date of last attendance thereat.

3. *Work or business carried on in the house.*

4. *Water-supply and milk-supply.*

5. *Sanitary condition* of the premises and surroundings.

6. *Previous cases* of the disease in the house or in the vicinity, or at the school or work-place.

In dealing with an outbreak of small-pox further enquiry must be made regarding the condition of each individual as to vaccination and re-vaccination, noting the dates. These should be supplemented by enquiries about the appearance in the house of rats (dead or living) in cases of plague, and about certain other domestic animals, *e.g.*, cows in cases of scarlet fever, and cats, fowls, or pigeons in cases of diphtheria.

Spot maps are maps of a district or town on which deaths or cases of various infectious diseases are noted on the locality when they occur. They are very important to sanitary officers as they give valuable graphic impressions of any groupings of such deaths or sickness. These epidemic spot maps should be employed for a short period only, since they are not of much value when they cover a period of several months or years.

3. Quarantine

In the modern acceptance of the term "quarantine" means arrest of communication with infected places except under certain restrictions. This is especially directed to the detention of healthy travellers after their departure from an infected place. The period of detention should cover at least the longest incubation period of the disease. In theory quarantine appears to be a very effective way of stopping communicable diseases, but in actual practice this has invariably failed. The disadvantages are that it imposes restrictions on commerce and causes inconvenience to travellers.

Quarantine may be (i) *inward*, *i.e.*, when quarantine is imposed on a healthy town for its own protection, or (ii) *outward*, when it is imposed on an infected town or village for the protection of the surrounding country. If the patient is removed to a hospital, and disinfection of the infected house is properly carried out, it is not necessary to keep the family under quarantine. If the case is treated privately, the household must be placed under quarantine until the last case has ceased to be infectious and the final disinfection has been completed. From a hygienic point of view the movements of all persons exposed to infection should be limited. Hence quarantine has been conveniently divided into :

(*a*) *International Quarantine.*—This consists in compulsory isolation at the port of all persons coming from an infected place, or of persons who have been in contact with any case of infectious disease against which quarantine has been imposed.

(*b*) *Scholastic Quarantine.*—Since children are more susceptible to infection, it is necessary that due measures to check the spread of the disease should be taken. Children from an infected house during the period of quarantine should not be permitted to attend the school until the last case has ceased to be infectious. Closing of schools should be enforced unless there be a clear prospect of preventing the spread of the disease. If the attendance is greatly reduced by absence or exclusion of a large number of students it is advisable to close the school. (See Medical Inspection of Schools).

(*c*) *Domestic Quarantine.*—This becomes often necessary for members of an infected household. In the case of smallpox every member of such a house should be placed under a strict watch for a period of at least ten days after the last contact or until such persons are successfully vaccinated. Quarantine should also be insisted upon milkmen (*goalas*), tailors, etc. All persons, particularly children, should be strictly prohibited from entering into an infected house. It is also necessary to prevent the importation of rags, jute, etc., from infected places or ports.

Objections to Quarantine.—The objections to quarantine are as follows :

1. The infective period in some diseases being much longer, the infected persons and the contacts may carry infection for a longer period than can well be covered by quarantine.

2. Quarantine very often interferes with food-supplies, and may thus cause privation and predisposition to disease ; and by interfering with trade it alters prices and affords strong temptation for evasion.

3. The association of the healthy with the sick in a place (lazaretto) is not only undesirable, but tends to keep the disease alive.

4. The disease is very often concealed owing to fear of quarantine.

A modified system of quarantine is therefore of special value in India, and consists in "making all arrivals from an infected district take out passports which bind them to present themselves for inspection daily for a period of ten days. Suspected persons are detained and isolated, and beggars and others, who can give no address and who cannot be relied on to report themselves, are also liable to detention. If a passport-holder fails to report himself he can at once be hunted up and dealt with as best as possible." This system has been practised in Madras with much success.

4. Immunity

By *immunity* is meant non-susceptibility of a given disease or a given organism either under natural conditions or under conditions experimentally produced. Jenner in the latter part of the eighteenth century first achieved a triumph in the prevention of smallpox by means of vaccination, and further progress was made in this direction by the researches of Pasteur in hydrophobia and anthrax ; Koch in tubercle ; Loeffler, Behring, Roux, and Kitasato in diphtheria, tetanus, and pneumonia ; Haffkine in plague and cholera ; Ross in malaria ; and Wright in enteric.

For purposes of description immunity may be classified as follows :

A. Natural		
B. Specific	1. Acquired (from disease)	*a.* Permanent.
		b. Of moderate duration.
		c. Of short duration.
	2. Artificial	*a.* Active or isopathic.
		b. Passive or antitoxic.

A. **Natural or Innate Immunity.**—This form of immunity is possessed by a man or animal either from birth or acquired during growth by virtue of its species, race, or individual peculiarities. As instances may be mentioned, the immunity of hens against tetanus, and of goats, sheep, and rats against tubercle. Certain races of mankind are immune to certain diseases—the negro is said to be immune to yellow fever (racial immunity). Again, some families are more susceptible to certain diseases than others. Absolute immunity, either to infection or intoxication, is, however, impossible, and even a hen may develop tetanus if the dose be large. It seems probable that all men possess a certain amount of resistance against all micro-organisms, but this power of resistance varies with different individuals. It is a known fact that in times of epidemics all who have been exposed to infection do not take the disease, and even in those who take it some will have severer or even fatal attacks.

B. **Specific Immunity.**—This may result either by passing through a specific disease, or as a result of artificial inoculation.

1. **Acquired Immunity.**—It has long been recognised that an attack of an infectious disease confers a certain amount of immunity on a person from a second attack. The degree of immunity, however, varies, and may be :

(*a*) *Permanent*, *i.e.*, very strong, and may last for a considerable period, and often for the whole life of the individual, as in smallpox.

(*b*) Of *moderate* duration as in measles, diphtheria, etc.

(*c*) Of a very *short* duration as in cholera, influenza, etc.

2. **Artificial Immunity.**—There are two methods of artificial specific immunisation : they are known as *active* or *isopathic*, and *passive* or *anti-toxic*.

(*a*) *Active or Isopathic Immunity.*—This is obtained by inoculation (i) with living virulent virus, (ii) with living yet attenuated virus, (iii) with dead virus, (iv) with bacterial cellular substances of the same, and (v) with dissolved toxic products of bacteria.

By repeating these injections in gradually increasing doses at suitable intervals a very high degree of immunity is ultimately produced against the particular organism that has been used for the injections. It is obvious, however, that such a method of inoculation can only be *preventive* as it takes a long time to develop. It can never be curative as the immunity must be developed before the onset of the disease. Once produced, however, it affords protection for a long time.

The term *vaccination* is applied to all methods of protective inoculation, and the attenuated cultures or toxins which are used for this purpose are spoken of as *vaccines*.

(*b*) *Passive Immunity.*—This depends upon the fact that if an animal be immunised to a very high degree by the previous method, its serum, when injected into a susceptible animal, will confer immunity upon it provided that it is introduced at the same time as infection occurs or even a short time afterwards. This method, therefore, can be applied as a *curative* agent, but the passive immunity thus conveyed only lasts for a short period, because in this case there is no active production of " antibodies " in the blood.

When the serum of an animal is used in this way for the production of passive immunity in another animal it is found that its effects differ according to the original method of inoculation. If the micro-organisms themselves are used (whether living or dead) the serum is markedly *bacteriolytic*, but it has little power of neutralising toxins : it is therefore said to be *anti-microbic*. On the other hand when filtered toxins are used for the original inoculation the serum of the immunised animal

has the power of neutralising the toxin, and it is said to be *anti-toxic.*

5. Disinfection

Disinfection means destruction of the specific virus of infectious diseases. *Disinfectants* or *germicides* are substances which destroy pathogenic microbes, *i.e.*, those which cause communicable diseases and so prevent them from spreading. Disinfectants must not be confounded with *antiseptics*, or substances which stop bacterial growth and thus prevent or retard putrefactive changes, *i.e.*, decomposition of vegetable or animal matter. *Deodorants* or *deodorisers* oxidise products of decomposition and so absorb or destroy offensive smell.

Practical disinfection is utilised for :

1. Destruction of microbes deposited on walls, crevices, floors, surfaces, etc., of rooms, furniture, and other domestic articles ;
2. The destruction of infectivity of excreta and other discharges ;
3. Preventing the spread of infection by men ; and
4. Destroying *in situ* such microbes as, though pathogenic, have also an extra-corporeal or saprophytic existence.

It is not enough to know that a substance is a disinfectant, but the quantity to use and the degree of concentration required are important factors ; it is also necessary that the disinfectant must come in direct contact with the micro-organisms. Some deodorants destroy offensive odours by simply substituting an agreeable or some other strong smell without destroying the organisms giving rise to putrefactive odours. These are worse than useless.

For practical purposes disinfectants may be classified as follows :

I. Natural.
II. Physical.
III. Chemical.

I. Natural Disinfectants

Fresh air and sunlight are the natural disinfectants and kill most germs. By the process of desiccation all micro-organisms are sooner or later attenuated in their disease-producing activities. Typhoid, tubercle, and diphtheria bacilli resist drying for a long time, gradually losing their vitality. In fact it has been proved that direct sunlight will kill typhoid bacilli within one-half to two hours, and diffused daylight in about five hours. According to Koch, tubercle bacilli are killed by the sunlight in from a few minutes to several hours, according to the thickness of the mass exposed. Drying on the other hand resists multiplication of bacilli, and putting in the sun and air of bedding, clothes, and other articles often secures the desired degree of dryness, while the oxygen of the air exercises a toxic influence on the organisms that may have been harboured in those articles.

Sunlight is a strong germicide and aids disinfection to a grêat extent. Direct solar rays are more powerful than diffused daylight. Although a large number of micro-organisms, *e.g.*, of diphtheria, plague, etc., are destroyed by the rays of the sun, yet as a disinfectant sunlight cannot absolutely be relied upon. The ultra-violet rays of the sun have a powerful restraining action on the growth of bacteria.

II. Physical Disinfectants

Physical disinfectants include heat in its various forms and may be applied as:

A. Dry heat:
1. Burning by fire.
2. Hot dry air.

B. Moist heat:
1. Boiling.
2. Steam.

A. Dry Heat.

1. *Burning.*—This is the best means of disinfection, and should always be employed for articles of small value, *e.g.*, rags in which discharges have been received, pillows, old mattresses, etc. The destruction of all these articles is usually carried out in a small destructor-furnace which

should also form a part of the disinfecting station. If carried out in the open air small unburnt particles carrying infection may be scattered by wind. Cholera and enteric excreta should be burnt by mixing them with sawdust and kerosene oil to ensure their thorough and complete destruction.

Cheap dwellings like huts that can readily be reconstructed had better be disinfected by fire, especially where diseases like plague have occured.

2. *Hot Dry Air.*—Formerly this was the principal method for disinfecting clothing, bedding, etc. But to ensure the destruction of bacteria and spores the temperature must be high and the heating prolonged. It has little power of penetration, and requires many hours for the centre of a mass of bedding to attain the required temperature for sterilisation, while some articles and fabrics are distinctly injured by the prolonged heating. For these reasons disinfection by dry heat has been replaced by steam disinfection, which has many advantages. The only advantage of this method is that leather goods, india-rubber, fur, bound books, etc., are not damaged by it.

B. **Moist Heat.**

1. *Boiling.*—Thid is one of the most efficient methods of disinfection. Infected articles can be disinfected within about 20 minutes by boiling. It takes about 10 minutes to kill typhoid bacilli at a temperature of 140° F. and 5 minutes for comma bacilli at 126° F. Spores of many pathogenic micro-organisms are killed by boiling for 5 minutes. On the other hand *Bacillus anthracis*, *B. tuberculosis*, and *streptococci* of puerperal fever require boiling for a longer time for their destruction. This method is very often resorted to for disinfecting beds, linen, etc. Clothes stained with blood and fæces should first be cleaned with soap and water, and then subjected to boiling. An addition of 2 per cent. of washing soda accelerates the germicidal power of boiling water. The disadvantages of this method are that it is slow, and not suited for woolen materials which shrink, and that it fixes albuminous stains.

2. *Steam.*—This is the most efficient and practical way of applying moist heat for purposes of disinfection. It enables a higher temperature to be reached without any damage to the articles, and has a greater penetrating power than dry heat. It will destroy all micro-organisms and spores at a temperature of 212° F. in five minutes, whereas hot dry air would require a temperature of 250° F. for four hours. Steam used may be either *current, saturated,* or *superheated,* and may be used under *low* and *high pressure.* When steam is generated at the ordinary atmospheric pressure and at a temperature of 100° C. (212° F.) and allowed to escape, it is called *current steam.* In steam disinfection the term *low pressure* is used as equivalent to current steam. When steam is generated by boiling water in a closed vessel, *e.g.* in a steam boiler or kettle, it accumulates underpressure, and the longer the water is boiled the greater will be the pressure. The steam so generated is called *saturated steam,* and is not only compressed into a small volume but is of a higher temperature. If all the water in the vessel be converted into steam and the process of heating continued, the imprisoned steam is highly raised in temperature, *i.e.,* it becomes *superheated.* This superheated steam has properties similar to those of a dry gas, which being a bad conductor of heat has no value as a disinfectant. Saturated steam readily conveys heat, and condenses to $\frac{1}{1600}$th part of its original volume as soon as it comes in contact with articles slightly cooler than itself, and by giving off its latent heat becomes smaller in volume, consequently more steam is drawn into the partial vacuum thus produced, and the process is repeated until every portion of the article is acted upon by the steam. When disinfection is complete no further condensation of the steam occurs. With superheatad steam disinfection occurs in the same way as with dry heat. Therefore disinfection by saturated steam should always be preferred on account of its more rapid and thorough penetration. The term "high-pressure steam" means saturated steam as distinguished from current steam generated at atmospheric pressure. Even in high-

pressure disinfection a current of steam may be used, and Robertson has experimentally proved that such a current is the most certain method of securing absolute penetration and disinfection, especially suited for bulky articles. The low-pressure disinfectors obtain the steam from a boiler which forms a jacket round the disinfector—the water in the jacket being treated by a furnace placed underneath, while a high-pressure one always derives its steam from a separate boiler.

Current steam disinfectors although cheap at the outset are expensive in the long run because they consume more fuel. It should be noted that the higher the pressure of the steam the more rapid the penetration, and the less time required for disinfection. A temperature of 115° to 120° C. for twenty minutes is trustworthy in all cases.

Steam Disinfecting Station.—A disinfecting station should consist of two rooms—one for the infected and the other for the disinfected articles. Each room should have a separate entrance and be completely separated from the other by a wall, into which the stove is built, which communicates with both the rooms. The infected articles should be placed on trays which can be easily introduced or removed from the disinfector. The time required for disinfection depends on the bulk and the nature of the infected articles and the pressure of the steam employed. There should be arrangements for ascertaining the temperature of the interior of the stove at any time.

Of the high-pressure disinfectors the better known ones are the *Washington-Lyon*, the *Equifex* (*Geneste-Herscher*), and that of *Goddard, Massey, and Warner*; while the *Reck's apparatus* and *Thresh's Current Steam Disinfector* are examples of low-pressure ones.

1. *The Washington-Lyon Disinfector* is an elongated cylindrical boiler oval in section and with a door at each end. The disinfecting chamber is surrounded by a jacket, and the steam, usually worked at a pressure of 10 to 20 lbs. per square inch, is obtained from a separate boiler. There is an arrangement for producing a vacuum by aspirating air out of the chamber. A current of steam is first passed through the chamber, and when disinfec-

tion is complete the steam is allowed to escape, and the articles removed. It usually takes about fifteen to twenty minutes for disinfection. The chief use of the jacket is to heat the chamber before steam is introduced into it, and to prevent condensation. It also assists in drying the disinfected articles after the steam is allowed to escape.

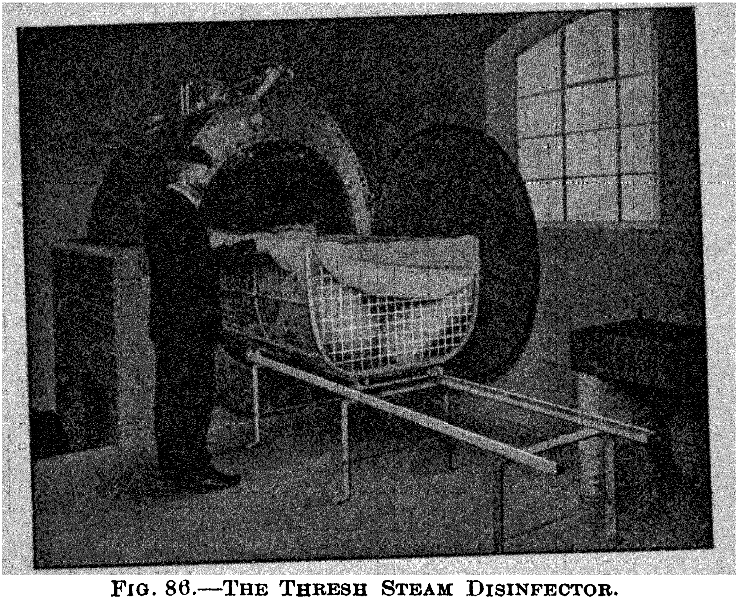


FIG. 86.—THE THRESH STEAM DISINFECTOR.

The disinfecting chamber is sufficiently large to admit bedding, etc., and is built into the partition wall between two rooms.

2. *The Equifex Disinfector* is worked with saturated steam at a 10 lbs. pressure at a temperature of 239° F. It is a high-pressure machine, the steam being derived from a separate boiler. The chamber consists of united steel, and has no jacket. The infected articles are placed on a wheeled cradle and the cylinder is furnished with separate doors for infected and disinfected articles.

Running through the chamber there is a coil of pipes for the steam to circulate which not only prevents condensation of steam, but also helps to dry the clothes after disinfection.

3. *Thresh's Current Steam Disinfector* consists of a chamber surrounded by a jacket. In this apparatus steam is generated from a saline solution, usually calcium chloride, which raises the boiling-point of water above 212° F. without any extra pressure. The boiler is fed with water from a cistern. Although it is a low current steam apparatus the steam is apt to be superheated. The time required for exposure is about thirty minutes. This apparatus is simple, cheap, and efficient, and does not require a separate boiler. It is best suited for use in small hospitals and municipalities.

It should be remembered that some fabrics are damaged by heat; woolen materials shrink when moist heat is applied and acquire a distinct yellow tinge when exposed to steam at 260° F. for about thirty minutes. Feathers become yellow or brittle after an exposure of four hours to moist heat at 260° F., silk, cotton, and linen will stand a moist heat of 260° F. for half an hour and dry heat of 230° F. for four hours with little damage. The majority of substances will stand a temperature of 230° F. without much injury.

III. Chemical Disinfectants

The exact manner in which the chemical disinfectants act has not yet been fully understood. The degree of ionisation of a solution may possibly have an important bearing on its disinfecting efficiency. Briefly, they act (*a*) by oxidising the protoplasm of the bacteria; *e.g.*, the halogen compounds, bleaching powder and potassium permanganate liberate nascent oxygen; (*b*) by coagulating the protoplasm of the bacteria, the phenols and their derivatives; (*c*) by ionic coagulation, the metallic salts; and (*d*) by emulsoid action and absorption. Admitting the value of the disinfectants there are certain limitations. For instance, the presence of electrolytes may

lower their value ; oxidising agents give up oxygen so rapidly that they soon become inert ; and lastly the metallic disinfectants do not penetrate readily. The temperature has also some significance. For instance, the germicidal value of phenol increases 7 to 8 times with every 10° C. rise of the temperature. Warm solutions are therefore more useful and should be used.

The choice of a germicide depends on the nature of the substance to be disinfected as also upon the resistance of the virus. Thus, perchloride of mercury 1 in 1000 solution, or carbolic acid 2.5 p.c. solution, will not kill the spores of tetanus. Whereas a weak solution of hypochlorite will sterilise water, a strong solution is needed to disinfect fabrics. The choice of the disinfectant, its strength, the time of application, the temperature of the solution and the method of application all require careful consideration for each particular class of infection.

The following are the requirements of an efficient disinfectant :

1. It must be a powerful germicide and rapid in action.

2. It should have a definite efficiency for particular organisms in given conditions, and should be permanently homogeneous.

3. Its chemical properties should be such as to render it fit for ordinary use and not rendered inert by fæcal or any polluting material, *i.e.* it should be stable in the presence of organic matter.

4. It should not have any injurious effects on human tissues and materials submitted for disinfection.

5. It should be soluble in water or form a uniform emulsion in all proportions.

6. It should be fairly cheap, and not act on metals, and be neither toxic nor caustic.

7. It should have a high solvent power for grease.

Such an ideal disinfectant is not known, therefore considerable discretion is necessary in the use of the known ones.

In order that the different disinfectants may be used with certain amount of precision it is essential to have some idea of the relative potency of these substances.

Therefore a standard method of testing the various disinfectants under precisely similar conditions is of considerable importance. This is done by comparing with phenol, a method devised by Rideal and Walker. The minimal concentration of phenol which will kill certain special micro-organism under certain special conditions in a certain length of time is first determined, and then the concentration of some unknown disinfectant which will produce the same effect under the same conditions is determined. The concentration of the phenol divided by the concentration of the unknown disinfectant gives a ratio called the *Rideal-Walker or Carbolic Acid Coefficient* of the disinfectant tested.

Martin and Chick (Lister Institute) modified Rideal-Walker and recommended an emulsion of fæces for the test.

The following chemicals are ordinarily used :

Carbolic Acid Powder.—This is chiefly used as a deodorant, but is of questionable value.

Lime.—Quicklime is a most useful disinfectant. A 1 p.c. solution kills non-sporing bacteria in a few hours. A 3 p.c. solution kills typhoid bacilli in an hour and a 20 p.c. solution added to fæces disinfects in an hour. It can be used to purify water, to disinfect stools, floors, stables, etc. It must be fresh and a good sample should not contain any chalk and should not effervesce with dilute mineral acids. For disinfection of stools equal portions should be used and thoroughly mixed with a stick and allowed to stand for two hours. The perfunctory sprinkling of lime over stools is useless. The powder absorbs moisture and CO_2 from the air so that it must be freshly burnt to be of value. As a disinfectant it is used in the form of milk of lime which is prepared in the following manner : 1 quart of small pieces of quick lime is added to 1½ pints of water ; this makes a dry hydrate of lime in powder, one pint of this is added to a gallon of water and the resulting milk of lime is utilized for the disinfection.

Perchloride of Mercury (Corrosive Sublimate).—It is a powerful and cheap germicide. It destroys all forms of

microbic life in relatively weak solutions. A solution of 1 in 1000 kills anthrax, diphtheria, glanders, typhoid bacilli and the vibrios of cholera in ten minutes and if the solution is 1 in 500 it destroys spores. There are certain drawbacks to its use, viz., (*a*) it acts upon metals, (*b*) its germicidal property is neutralised by its coming in contact with albuminous substances when it forms an insoluble albuminate of mercury, (*c*) it is not a good disinfectant for linens.

It is highly poisonous, and as it forms a colourless and odourless solution it is usually coloured with some harmless aniline dye to avoid accidental poisoning. In the form of tablets they are commonly sold as "soloids" or "solubes," and one tablet in a pint of water forms a lotion of the strength of 1 in 1000.

The addition of acids or salts (hydrochloric or tartaric, sodium or ammonium chloride) prevents or reduces the formation of insoluble compounds and increases its solubility. The following solution of corrosive sublimate is recommended for disinfecting purposes : Half an ounce of perchloride of mercury, 1 oz. of hydrochloric acid, and 1 gr. of aniline blue, to 3 gallons of water form an efficient lotion which costs only a few annas.

Mercury Iodide is less poisonous, and does not precipitate albumin. Although it is not soluble in water it is dissolved in excess of potassium iodide and sold under the name of mercuric potassium iodide. It can be incorporated with soap. A solution of 1 in 1000 is ordinarily used for disinfection.

The Coal-tar Disinfectants.—These chiefly consist of (*a*) hydrocarbons and inert oils and bases ; (*b*) phenols and phenol like bodies, cresols and similar products ; and (*c*) emulsifying agents such as soap, resins, albuminoid bodies and water. The real germicidal agents in the different coal-tar preparations are chiefly the phenols, cresols and their higher homologues. Soaps and resins are usually employed to help emulsification, but these are easily acted upon by such eletrolytes as sodium chloride, calcium salts and organic matter. These disinfectants are therefore useless for urinals and for use

on board ship. Besides carbolic acid many coal tar preparations are on the market and are of much value. They are mostly of a dark brown colour, form a milky emulsion with water, and have the advantage over carbolic acid in being practically non-poisonous and cheaper. They are :

(i) *Carbolic Acid* or *Phenol.*—Phenol is crude carbolic acid and is obtained from distillation of tar. It is very slightly affected by albuminoids, and is generally stable in the presence of organic matter at ordinary temperatures. It is poisonous and caustic. A 2 per cent. solution will kill ordinary sporeless bacilli in from a few minutes to ten hours, while it is practically useless for spore-bearing organisms. The disinfecting power of carbolic acid is greatly increased by the addition up to saturation of common salt or hydrochloric acid. Its chief value is as a standard, as its disinfecting power is comparatively low. It is cheap and does not affect metals, but has a caustic effect on the hands so that it must be applied with a mop or a spray. It is well adapted for mopping floors, side walls and ceilings. As a disinfectant its working strength should be 1 in 20.

(ii) *Phenyl.*—It is a very popular disinfectant and is twice as powerful as carbolic acid and has the advantage of being cheap.

(iii) *Izal.*—It is an exceptionally powerful germicide for bacilli of the coli-typhoid group. A solution of 1 in 500 completely disinfects typhoid stools in fifteen minutes, and 1 in 600 renders typhoid urine aseptic in five minutes (Klien).

(iv) *Cyllin* is seventeen times more powerful than carbolic acid, and is cheap and efficient ; useful for disinfecting privies and drains in the strength of 1 in 150.

(v) *Hycol* is also a coal tar derivative and has a pleasant smell. As a disinfectant it is similar to cyllin and is about twenty times stronger than carbolic acid. It forms a dark brown solution with water.

(vi) *Creolin.*—It is an emulsified cresol in a solution of hard soap and is about ten times less weak than

phenol as a disinfectant. Albumin makes it somewhat inert.

(*vii*) *Lysol* is a dark-coloured liquid and a solution of cresol (50 per cent.) in neutral potash soap. It is soluble in water, and a 2 per cent. solution destroys ordinary bacteria in an hour. It is more effective than creolin and not readily acted upon by albuminous fluids. The working strength of the solution should be 1 in 25.

(*viii*) *Chinosol.*—This is an odourless non-irritating powder, and a solution of 1 in 1200 forms an efficient germicide.

Potassium Permanganate.—It acts as a powerful germicide when in strongly acid or alkaline solution, but it stains fabrics brown. It is generally used as a powerful disinfectant in 5 per cent. solution, but in less than a half per cent. solution it acts only as a deodorant. It is expensive and very soon becomes inert.

Soap.—Common soap is one of the most widely used disinfectants and affects most of the disease germs. The germs are actually killed by the alkali of common soap and by washing away the grease they are exposed to the action of other powerful disinfectants. Soaps are incompatible with most disinfectant substances, but not with all.

Sulphurous Acid.—This is used as a gaseous disinfectant and is usually obtained by burning sulphur. It is very poisonous to mammalian and insect life, and its action as a germicide depends upon the presence of moisture as the dry gas is practically inert. It is especially valuable for disinfecting ships, cars, graneries, stables, outhouses and places infested with vermins. It bleaches all colouring matters of vegetable origin and many aniline dyes, attacks all metals and acts on cotton and linen fabrics. All the openings of the room should be completely closed and about a pound of sulphur broken and moistened with methylated spirit should be allowed to burn in a vessel. The room should be kept closed for a few hours. One pound of sulphur when burnt gives off 1.12 per cent. of SO_2 for 1000 cubic ft. of space, and three pounds of sulphur are usually required for disinfecting

the same area. For fumigation sulphur is used in the following ways :—

1. *The Pot Method.*—This is the easiest and cheapest, and is done by putting powdered sulphur in large iron pots placed in a tub of water. This water furnishes the moisture necessary to hydrate the SO_2. The sulphur is soaked with alcohol and if arranged with a hollow in the centre in the form of a lake it burns quite well. Sulphur candles are available and may also be used.

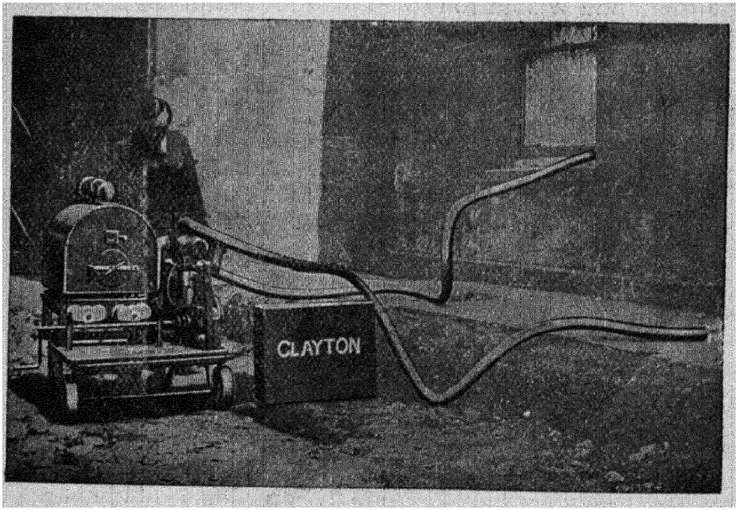


FIG. 87.—CLAYTON DISINFECTOR
Showing room undergoing disinfection.

2. *Liquid Sulphur Dioxide.*—This is rather expensive but the gas is liberated rapidly. It has the further advantage of avoiding accidental fire.

3. *The Clayton Disinfector.* The principle underlying this method is the generation of special combinations of oxygen and sulphur. This is done by burning sulphur in an iron generator, and the machine abstracts the air from the room to be disinfected by the use of a fan and passes it over burning sulphur. The resulting products

of combustion are air cooled by passing through a kind of radiator before reaching the fan. These are then driven through a hose-pipe into the room to be disinfected, from which by means of a return pipe the air passes back from the room to the generator (*See* Fig. 88). The gas contains over sixty times the quantity of SO_2 (sulphuric anhydride) than that formed by burning sulphur in the open air.

Clayton apparatus is the most effective method of disinfection and can be adopted without interference with, or removal from, an infected room of its usual contents. It has great penetrating power and is fatal

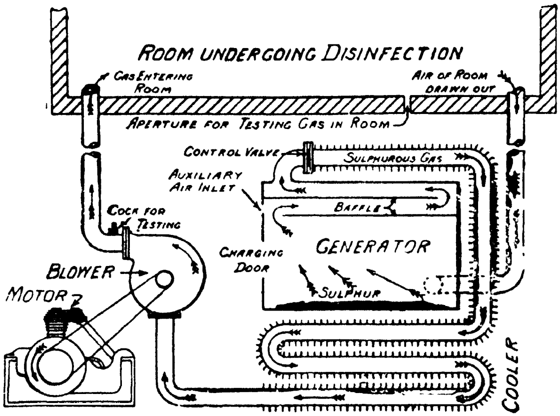


FIG. 88.—SECTION OF A CLAYTON DISINFECTOR.

to all pathogenic organisms with the exception of the spores of anthrax. This system can be used effectively for the destruction of rats, bugs, lice and other vermins and their eggs.

Chlorine.—It is an irritant and heavy gas, and the disinfectant and deodorant properties depend on its affinity for hydrogen. Therefore it is essential that a certain amount of moisture should be present. As compared with SO_2 its bleaching properties are more marked. *Chlorogen* is a hypochlorite fixed in an alkaline solution,

but is weaker in available chlorine. *Chloros* was used by Houston for sterilising water, but to be of any use it must have 12 to 14 p.c. of available chlorine. In India it is not sufficiently stable to be of any practical use. Hutchison recently introduced "*Electrolytic Chlorogen*" which has a greater stability under Indian conditions, and the available chlorine is low - 2½ to 3 p.c. It is produced by electrolysis of brine and keeping the temperature uniformly low to prevent evolution of chlorine gas.

Chlorine is usually used in the form of *chloride of lime*, which should contain about 35 per cent. of available chlorine. It is also used as hypochlorite of soda (Chloros). The chloride of lime is an unstable compound. For disinfecting purposes chlorine must always be used in excess. About eight ounces of the powder with three pints of water are required for a room 10 ft. square. Bleaching powder does not damage articles to any great extent. Where the amount of organic matter is small, and the objects are not likely to be injured, the hypochlorites are among the best of known disinfectants when used fresh.

Formaldehyde. -This is used as a gaseous disinfectant, the gas being liberated from tablets by heating in some special form of lamp, and it has largely replaced sulphur of recent years. It may be readily generated by pouring formalin on permanganate of potash. The proportion of the two substances which gives the best results and the driest residue, is two parts of formalin to one part of permanganate. The method is effective, simple, rapid, and by virtue of the inexpensive apparatus required preferable to the older and more cumbersome methods. For a space of 2000 cubic ft. 10 oz. of the permanganate and one pint of formalin are required, the reagents being mixed or added the one to the other in an ordinary galvanised iron pail. The crystals, which are better crushed, are put in first, and then the formalin is poured on them. There is time for the operator to withdraw, and the period of disinfection should be six hours. Heat and moisture are essential for efficient disinfection. From 60 to 70° F. is a proper temperature, while it is well to

render the air of the room moist in a dry country. For purposes of fumigation it has the advantage over sulphurous acid and chlorine in having lower density which gives it greater diffusibility and ready power of penetration. It is harmless to most colours and most surfaces. It is not an insecticide and is useless as an antiplague measure.

General Preventive Measures against Epidemic Diseases

Since the nature and mode of propagation of the epidemic diseases differ from one another, it follows that the measures appropriate for their prevention must necessarily vary. It is therefore not possible to lay down any definite and formulated rules that will help the student to cope with all the diseases. Thus, malaria, which is carried by mosquitoes, will require measures quite different from those necessary for diseases like cholera or enteric fever, where the infection is disseminated mainly by the intestinal discharges of the patient. Moreover, the same disease, may at different times, be propagated by different routes. For instance, diphtheria may at one time be spread by personal contact and at another time by the distribution of the infected milk. To be effective, the preventive measures must therefore be based on a knowledge of the etiology of the disease against which such steps are required and its different modes of transmission. Certain general principles which will apply practically to all infectious diseases may be discussed.

In every case of an epidemic it is of primary importance to obtain information of the first cases of the disease. This will enable the sanitary officers to take effective measures against the spread of the epidemic. It is rarely that in an outbreak of an infectious disease the early cases are promptly recognised. In some instances through wilful suppression, more often through want of familiarity of the diseases, that these cases pass unrecognised. The possibility of the presence of carriers in the affected area should not be lost sight of. These

carriers should be detected and suitable steps taken against them. Particular attention should be paid to the poorer classes living in the *bustees* under the most insanitary conditions. Common lodging houses require careful watching in view of the liability of the people who frequent these houses to contract and carry about infectious diseases.

Every care should be taken to localise the infection by preventing unnecessary association of the sick with the healthy. In the event of an infectious disease occurring in a private house, the patient should whenever possible be removed to some safer quarter. Those persons who came into direct contact with the patient should be kept under observation till the period of incubation is over.

Overcrowding should be prevented, and ample ventilation enforced in the sickroom. Refuse should not be allowed to accumulate and the articles requiring disinfection should be done with all possible haste.

The effect of sunlight and fresh air should not be forgotten. Special care should be taken with regard to the excreta and other discharges from the sick. The discharges of the nose and throat of diphtheria, measles, etc., should be treated as infective. The bedding, clothing and other articles which were used by the patient should be similarly dealt with. It is desirable, if not essential, that all these soiled articles should be destroyed by fire, or else they should be subjected to a thorough disinfection. The stools of cholera and enteric patient should be first disinfected and then disposed of as safely as possible, bearing in mind that on no account should they run or soak into any sources of domestic water.

Always examine the water-supply. The well or the tank may be polluted by animal refuse, leakage from *katcha* drains and foul ditches, and washings of infected clothes. Under no circumstances should this water be used for drinking purposes. If however the only source of water-supply is not above suspicion, careful instruction should be given to boil the water before drinking.

Ordinary domestic filters should not be relied upon. Arrangement should be made to disinfect the water by suitable means. The use of bleaching powder for this purpose should not be lost sight of.

If however the infection is traced to the milk-supply, the cleanliness of the cans, the purity of the water used in them, the health of the persons engaged in the dairies, the conditions of the dairies, the way the milk is stored and carried require a thorough investigation. In every case insist on boiling the milk before use.

In any campaign against infectious disease success depends largely on the co-operation of the people. It is therefore necessary that they should be acquainted with the precautionary measures which they can adopt against the epidemic which threatens and what vigilance is necessary with regard to its early symptoms. Printed handbills, placards, popular lectures with magic-lantern demonstrations, and in certain cases house to house visitation by competent and discreet persons may help in quieting unnecessary alarm and assisting the ignorant masses to do what is needful for their own safety.

Practical Methods of Disinfection

The chief point to be aimed at is the efficiency of the disinfectants used and to see that there is nothing to disturb their efficient working. Since success depends upon attending to the minute details, no part of the work should be left to inexperienced persons. The presence of albuminous matters, the nature of the materials to be disinfected, the character of the water used for the dilution of the disinfectant fluid, the strength of the solutions, and the mode of application all require careful attention. Hard water interferes with the property of the disinfectants, therefore soft water should always be used. Disinfectants again act better at a high temperature and are powerful when in a state of emulsion than when in solution.

Practical disinfection includes disinfection of the sick room, inhabited rooms, persons, clothing, effete materials, dead bodies, bath rooms, etc. And since the infec-

tive organisms cannot be seen or located, it is necessary to apply the disinfecting agent to every inch of the surface of the room and all its contents so that the possibility of escaping the particular spot will be nil.

The methods employed for disinfecting a room will vary with the nature of the infection. Thus in the case of plague our efforts should be directed against rats, mice, fleas and the distinfection of the plague bacillus ; in case of cholera or typhoid fever attention should be paid to the urine, fæces and articles soiled by them. For all practical purposes fumigation with formaldehyde or by means of a Clayton Disinfector answers well. Common articles, such as, beddings, carpets, rugs, etc., which are liable to be infected should be treated separately.

It is a good plan to boil infected clothes for about half an hour, but to boil them special arrangements must be made by municipalities not equipped with a steam disinfector. Where a steam disinfector is available all infected articles should be removed in gunny bags.

Ordinary Indian huts cannot be satisfactorily fumigated on account of their defective construction and of the space left between the walls and the roofs, as well as for the imperfectly fitting doors and windows. Fumigation is a failure unless the room is a brick-built one with tight-fitting doors and windows.

In proceeding to disinfect a room the floor should receive attention first, as the germs, the fleas, and other infected materials, *e.g.*, the vomited matter and stools of cholera patients, lie on the floor. Even in smallpox cases the infected particles of skin which are carried about by the air and deposited on the walls and ceilings, gradually settle on the floor. Moreover, the poorer classes in India usually lie on the floor, which they infect. The walls, if necessary, may be disinfected up to a man's height. The floor should be thoroughly washed with acid solution of perchloride of mercury 1 in 1000. After the disinfection of the room the privy and drain should receive attention. The platform (*i.e.* the seat arrangement) of the privy and the floor of the collecting chamber should be scrubbed and washed with some antiseptic lotion,

e.g. cyllin or chloride of lime, and the privy pan removed and destroyed and replaced by a new one. The cesspit should be cleaned and disinfected and the walls lime-

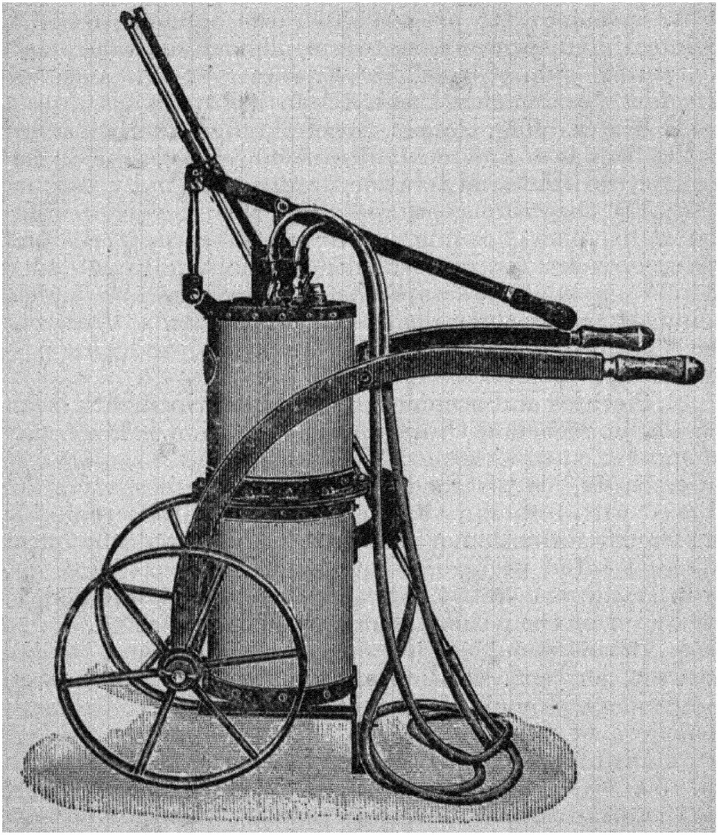


FIG. 89.—THE EQUIFEX SPRAY-DISINFECTOR.

washed. The privy requires to be disinfected in cases of cholera, typhoid, and dysentery. The house-drain, if any such exist, should also be cleaned and disinfected with cyllin or chloride of lime solution.

Finally a search should be made for any infected articles, *e.g.* rags, etc., that may have been thrown in the garden or compound, and also for any accumulation of filth, *e.g.* dung, etc., which should be removed and burnt.

1. **Spraying.**—If proper apparatus cannot be had a disinfecting inspector with two men should go with a cart containing gunny bags, an Equifex sprayer and disinfectants, and engage themselves as follows :

1. The bedding, clothes, towels, etc., should be packed in the bags in a previously disinfected place, sealed, and sent to the disinfecting station for disinfection by steam.

2. Fill the disinfector, and spray with the disinfectant the walls, floors, ceiling, crevices and corners ; in fact all receptacles for dirt should be thoroughly attended to. Walls should be scraped before spraying. A practical point is to spray the walls from below upwards to prevent the solution running down the wall and producing discoloration.

3. Pictures and ornaments should be wiped with clean muslin moistened with disinfectant solution. They may be sprayed and subsequently wiped dry.

4. Boots, leathergoods, fur, silk, brushes etc., are treated with formalin vapour or sprayed with perchloride of mercury lotion. Books of little value should be burnt or else treated with formalin vapour.

5. Bathroom, spittoons, water-closets, cups and dishes, etc., used by the patient should also be disinfected.

6. Drains should be cleaned thoroughly and treated with a 5 per cent. solution of crude carbolic acid and all damp places should be sprinkled over with Calvert's carbolic acid powder.

7. Disinfectors should repeat the process over again and then wash themselves.

The disadvantage of this method is the discomfort experienced by the disinfectors in thoroughly carrying out the work. Disinfectors should wear either cotton or water-proof (Mackintosh) coat whilst at work. Solutions of mercuric chloride 1 in 1000, chinosol 1 in 1200, formalin 1 in 40, carbolic acid, and lysol are efficient for spraying.

The best time to disinfect a room is when the patient is dead or convalescent.

2. **Fumigation.**—This is an important method of disinfecting rooms, holds of ships, graneries, out houses, railway carriages, etc., and have a very wide range of application. Formalin and sulphur are chiefly used for fumigation. The room should be properly prepared by closing the doors and windows and it should not be opened until after about fourteen hours. And in all cases cultures of test organisms should be exposed in the room as controls. The method of using formalin has already been described. The sulphur is best used nowadays as Clayton Disinfector.

3. **Washing.**—The walls, ceilings, etc., may be washed with a solution of corrosive sublimate (1 in 5000), chloride of lime (1 in 100), or hypochlorite of lime (1 per cent.).

When a case of infectious disease occurs, in the absence of a competent medical adviser, the following simple rules should be observed* :—

1. Whenever a steam disinfector is available, all articles of bedding, carpets, hangings, etc., which are not likely to be injured by steam should be sent to the disinfecting station.

2. When a steam disinfector is not available, cotton and linen articles should be boiled for half an hour. Blankets and other woollen articles and coir fibre should be soaked for two hours in Izal solution. Cloth articles should be sprayed with a 5 per cent. solution of pure carbolic acid in water and exposed to the sun for three or four days. Leather articles should be sponged with 1 per cent. formalin solution.

3. Feeding and cooking utensils should be boiled for fifteen minutes. Immersion in a 20 per cent. *hot* solution of washing soda suffices, however, for most infectious diseases, but it will not serve in cases of infection by the *tubercle bacillus*. Table knives, mounted forks, and similar articles which are damaged by high temperatures should be soaked for two hours in a 1 per cent. solution of formalin.

* Lukis and Blackham, *Tropical Hygiene*.

4. The walls of the rooms occupied by the patient should be scraped and re-limewashed.

5. Furniture, floors, and woodwork should be scrubbed with hot water and soap.

6. Earthen floors should be saturated with a disinfectant preparation, either a solution of mercuric chloride, 1 part in 1000 of water, or kerosene emulsion with cyanide will serve.

7. The woodwork of the latrine used by the patient should be scrubbed with mercuric chloride solution and the floor saturated with the same solution.

Disinfection of Excreta and Discharges.—The excreta of certain diseases contain organisms of the disease, and if not properly disinfected or disposed of will be a source of further infection. Thus, the stools and urine of enteric, the sputum of phthisis, pneumonia and pneumonic plague, discharges from the nose and throat of diphtheria and measles, and the vomitted matter and stool of cholera patient, all require to be carefully disinfected. Carbolic acid 10 p.c., izal 5 p.c., cyllin 1 in 100, or chloride of lime may be used with advantage. But these require contact for 1 to 3 hours. All discharges from the mouth, throat, lungs and nose should be carefully disinfected, and infected rags, etc., burnt. The infected stool should be treated with good chloride of lime. For typhoid bacilli 1 p.c. solution of formaldehyde is quite effective.

CALCUTTA MUNICIPAL ACT, 1923

Restraint of Infection

Sec. 435.—Every medical practitioner who, in the course of his practice, becomes cognisant of the existence of any dangerous disease in any private or public dwelling-house, other than a public hospital, shall give information of the same with the least practicable delay to the Health Officer in such form and with such details as the Health Officer may, from time to time, require.

Sec. 436.—The Health Officer, or any other municipal officer authorized by him in this behalf, may, at any time by day or by night, without notice, or after giving such notice of his intention as may, in the circumstances, appear to him to be reasonable, inspect any place in which any

dangerous disease is reputed or suspected to exsist, and take such measures as he may think fit to prevent the spread of the said disease beyond such place.

Sec. 437.—(1) If it appears to the Health Officer that the water in any well, tank or other place is likely, if used for the purpose of drinking or for any other domestic purpose, to engender or cause the spread of any dangerous disease, he may, by public notice, prohibit the removal or use of the said water for such purpose.

(2) No person shall remove or use for such purpose any water in respect of which any such public notice has been issued.

Sec. 439.—(1) If the Health Officer, or any municipal officer authorized by him in this behalf, is of opinion that the cleansing or disinfecting of any building or any part of a building, or of any article therein which is likely to retain infection, or of any tank, pool or well adjacent to a building, would tend to prevent or check the spread of any dangerous disease, he may cleanse or disinfect such building, part, article, tank, pool or well and may, by written notice, require the occupier of such building or any part thereof to vacate the same for such time as may be prescribed in such notice.

Sec. 440.—(1) If the Health Officer is of opinion that the destruction of any hut or shed is necessary to prevent the spread of any dangerous disease, he may, after giving to the owner or occupier of such hut or shed such previous notice of his intention as may in the circumstances of the case appear to him reasonable, take measures for having such hut or shed all the materials thereof destroyed.

(2) Compensation not exceeding the value of the hut shall be paid by the Corporation to any person who sustains loss by the destruction of any such hut or shed.

Sec. 441.—No person shall let a building or any part of a building in which he knows or has reason to know that a person has been suffering from a dangerous disease,—

(*a*) unless the Health Officer has disinfected the same and has granted a certificate to that effect, and

(*b*) until a date specified in such certificate as that on which the building or part may be occupied without causing risk of infection.

Sec. 442.—(1) The Corporation may provide a place or places, with all necessary apparatus and establishment, for the disinfection of conveyances, clothing, bedding or other articles which have become infected; and when any articles have been brought to any such place for disinfection, may cause them to be disinfected either,—

(*a*) free of charge; or,

(*b*) in their discretion, on payment of such fees as they may from time to time fix in this behalf.

(3) The Health Officer, or any person authorized by him in this behalf, may disinfect or destroy, or, by written notice, direct the disinfection or destruction of any clothing, bedding or other articles likely to retain infection.

Sec. 443.—(1) No person shall, without previous disinfection of the same, give, lend, sell, transmit, or otherwise dispose of any article which

he knows or has reason to know has been exposed to infection from any dangerous disease.

Sec. 444.—(1) No person who is suffering from a dangerous disease shall enter, or cause or permit himself to be carried in, a public conveyance, nor shall any other person knowingly cause or permit a person in his charge and suffering from a dangerous disease or the dead-body of any person who has died from such disease to be carried in a public conveyance without—

(*a*) previously notifying to the owner, driver, or person in charge of such conveyance that he is so suffering, and

(*b*) taking proper precautions against spreading such disease.

Sec. 445.—(1) The owner, driver or person in charge of any public conveyance in which any person suffering from a dangerous disease or the dead-body of any person who has died from such disease has been carried shall immediately take the conveyance for disinfection to a place appointed under section 442, sub-section (1).

(2) The person in charge of such place shall forthwith intimate to the Health Officer the number of the conveyance and proceed to disinfect the conveyance.

(3) No such conveyance shall be used until the Health Officer has granted a certificate stating that it may be used without causing risk of infection.

Sec. 446.—(1) The Corporation may provide and maintain suitable conveyances for the free carriage of persons suffering from any dangerous disease or of the dead-bodies of persons who have died from any such disease.

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CHAPTER XX

PREVENTABLE DISEASES

MALARIA

MALARIA is a specific infectious disease caused by a sporozoon parasite and carried from man to man by the agency of certain species of mosquito. In man they inhabit the red blood-corpuscles, giving rise to pyrexia, exhibiting a characteristic periodicity, accompanied by anæmia and enlargement of the spleen.

The "malarial theorem" as Sir Ronald Ross calls it, may be stated as follows: Malaria in man is due to a minute parasite (protozoon) which lives and multiplies in the blood passing its trophic phase within the red blood-corpuscles. The parasites are introduced into men only by the bites of mosquitoes of the sub-family *Anophelinæ* of the *Culicidæ*, which have themselves become infected by sucking the blood of infected persons containing the gametes of the malarial parasite.

Geographical Distribution.—Malaria is a widespread disease. Broadly speaking it occurs with increasing frequency and intensity as the Equator is approached, and is more prevalent in tropical and sub-tropical countries than in those situated in the temperate zone. It is on the decrease in Europe, and its endemic areas are limited. In Asia it has a much more extensive distribution than in Europe. During the war of 1914 to 1918, malaria was a serious factor in Macedonia, Palestine, Mesopotamia and East Africa. It is found with varying degrees of frequency and intensity throughout India, Indo-China, Southern China, Burmah, Ceylon, the Malay Peninsula, etc. It is more prevalent in Lower Bengal and Assam than in other parts of India. In tropical Africa malaria

is at its worst from, and the West Coast of Africa is known to be the most malarious region in the whole world. Although Malaria is endemic in tropical and subtropical areas, it is possible that under the stimulus of wide movements of those infected, it may spread into temperate and even to sub-arctic regions, where normally it does not occur. Australia and Japan enjoy comparative immunity from this disease.

Race incidence and acquired immunity.—The question whether immunity is possible may be answered in the words of Manson as "yes" and "no." It is often asserted that one attack gives immunity, but this is not always so, as relapses very often occur. Occasionally, however, one severe attack, or repeated attacks, give a certain amount of protection to an individual for the rest of his life. On the other hand it is very common to find old inhabitants of malarial districts enjoying the best of health and perfect immunity. New-comers to India are more susceptible to attacks of malaria than old residents. Some races and certain individuals are, however, less susceptible of malarial influences than others, but very few are absolutely immune. The Chinese, the Malays, and some other dark-skinned races also appear to enjoy a comparative immunity—an immunity considerably less pronounced, however, than that enjoyed by the African and West Indian Negro. Koch has shown with a certain amount of precision that the apparent immunity of the Negroes, Melanesians, and other dark-skinned races is due to repeated and persistent infection in childhood. He observes that the proportion of infected children becomes less with each additional year until adult life when the person becomes free of the parasite and immunity is established.

Ætiology.—Factors which predispose to malaria are the conditions which favour the growth and spread of the anopheline mosquito.

1. *Season and Temperature.*—The chief meteorological factor affecting the incidence of malaria and determining its epidemiology is rainfall. Mosquitoes require a comparatively high atmospheric temperature to develop:

also a certain temperature is required to ensure infection from the full development of the protozoal infective organism within the mosquito. Consequently malaria abounds chiefly in warmer latitudes. Malaria is to some extent a seasonal disease. In temperate climates it is prevalent during summer. In India, the period of maximum intensity is from October to December ; it is next most common during the rains lasting from the middle of June to early October ; it is less prevalent during the dry first half of the year. It has been ascertained that the mean temperature of about 60° F. for sixteen days is necessary to allow the establishment of malaria infection.

2. *Local Conditions.*—Malaria is for the most part a rural disease, and towns are much less malarious than villages. Calcutta, for instance, is comparatively freer from malaria than its surrounding area. Malaria tends to follow the distribution of heavy rainfall. Intermittent and moderate rainfall—provided there is sufficient water collected for oviposition—is more favourable for the breeding of mosquitoes. In places where the mosquitoes abound the whole year round and the temperature is favourable for their growth ; rain-fall helps rapid dissemination of the infection by extending the area over which breeding of mosquitoes takes place. Roughly it may be stated that malaria is more prevalent in India during and after the period of heavy monsoon rains, particularly in places and localities where the drainage is inefficient or in any way obstructed. In places where malaria is endemic, *i.e.*, where the winter conditions prevent infection all the year round, it has been found that different types of infection occur according to the relation of the temperature to the sexual development of the different varieties of parasites. Thus, it has been found that the commencement of the *plasmodium vivax* infection preceeds the *falciparum* by at least a month.

3. *Soil.*—There is no evidence to show that malaria is in any way related to the mineral constituents of the soil. Soil only plays an indirect part in the ætiology of malaria by affording facilities for collection of water whereon mosquitoes can breed. Loose, porous, sandy,

alluvial soils, deep loamy marshy lands, with a substratum of clay affording capacity for the retention of water, and level countries presenting physical obstacles to underground drainage, are most favourable during a moderately high range of temperature, to the development of malaria (Hehir).

4. *Marshes, Tanks, etc.*—Water being essential for the breeding of mosquitoes, inhabited areas close to swamps, marshes, *jheels*, ponds, excavations (*dobas*), paddy-fields, etc., are as a rule malarious. Ravines are always unhealthy especially when covered with trees and plants. Villages adjoining irrigation canals and ditches are equally responsible for the propagation of anophelines. Canals and ditches not only breed mosquitoes but make the surrounding area sodden and damp.

5. *Rice and Jute Cultivation.*—A rice-field may be regarded as a type of swamp or marsh. In India without adequate subsoil drainage rice cultivation is injurious to the health of the cultivators. In certain districts of Bengal, where the cultivation of jute is carried on, facilities for the breeding of mosquitoes are afforded during the process of wetting of the stalks in pools and ponds of stagnant water. In fact these factors contribute largely to the high prevalence of malaria in Bengal. In endemic areas it might be justifiable to condemn their cultivation, but in a place where millions depend on rice crops for their very existence, a rigid attitude towards rice cultivation cannot be adopted But, whenever possible, rice cultivation should be prohibited in the vicinity of densely populated places.

6. *Railways in relation to Malaria.*—There is a good deal of truth in the belief that the construction of railways in India has helped to maintain and disseminate malaria, and some districts previously healthy have been made badly malarious by railway works. These act in two ways : (i) By the formation of burrow pits, which when converted into stagnant pools and marshes become breeding-places for mosquitoes, and (ii) by embankments, which cause obstruction to natural drainage. (*See Soil* p. 108).

7. *Predisposing Causes.*—Anything which lowers the natural resisting power—deficient food, excessive labour, chills produced by sudden fall of temperature, occupation of dark and insanitary houses which usually harbour mosquitoes, trying damp heat, etc.—predisposes one to attacks of malaria.

The Parasite.—The cause of malaria is a sporozoon parasite, of which there are three species which produce human malaria. These different species have been classified according to (i) the duration of their respective life cycles inside the human body ; (ii) their morphological characters ; (iii) the clinical phenomena they give rise to ; and (iv) the results of inoculation experiments.

The different parasites, and the diseases they give rise to, may be broadly divided into two groups—the *benign* and the *malignant.* Morphologically these are distinguished by the fact that the benign parasites never form crescent bodies, the malignant parasites, or at least the subtertian, form crescents. Clinically benign parasites rarely give rise to pernicious attacks, whereas the malignant parasites frequently do. The different kinds of parasites may be arranged as follows :

Benign	Quartan Tertian	Do not form crescents.
Malignant	Subtertian :	Form crescents.
	Quotidian—pigmented Quotidian—unpigmented,	Supposed to form crescents.

Some observers describe only three species of malaria parasite, giving rise to three clinical varieties of malarial fever. They are benign tertian, quartan, and subtertian or malignant tertian fever.

1. *The Benign Tertian* parasite (*Plasmodium vivax*) completes its asexual life cycle in forty-eight hours, and the clinical course of an attack is more or less definite. The patient is free from fever for forty-eight hours after the occurence of the rigor. When the parasite invades the whole corpuscle it becomes enlarged and pale : no crescent bodies are developed and the gametocytes are similar to, but larger than, the quartan. When uncomplicated, this variety rarely produces fatal results, but

unless treated from the very beginning it is apt to produce chronic debility, anæmia and cachexia.

2. *The Quartan* parasite (*Plasmodium malariæ*) unlike the benign tertain completes its asexual life cycle in seventy-two hours. Clinically this fever resembles benign tertian, but there are two complete days without an attack. Taking the day of the previous onset, an attack occurs every fourth day, hence the name "quartan." These parasites also do not form crescents.

3. *The Malignant Tertian* parasite (*P. falciparum*) is smaller than either of the foregoing varieties. Its infection is characterised by irregularity of fever, with considerable destruction of blood. Pernicious symptoms may supervene suddenly even in cases apparently not severe. Peculiar character of this parasite is that during the stage of multiplication it disappears from the peripheral blood and passes its asexual stage in the visceral capillaries. This variety is however most amenable to treatment by quinine, and is followed by rapid convalescence if properly treated.

The clinical manifestations vary according to the species of parasite, but pyrexia, slow development of anæmia, and other toxic symptoms are common in all varieties. In all varieties parasites are found in the red blood-corpuscles.

The malarial organism exists in nature as a parasite in man and in certain species of mosquitoes. The parasites are found in the salivary glands of the mosquitoes as fine fusiform bodies, and vary in size during development, being in man from 1 to 8 μ, in the mosquito from 8 to 40 μ. In the human host it develops within the red blood-cell and possesses amœboid movements which enable it to change its shape and position.

The parasite possesses two cycles of development: *asexual* a nd *sexual*. By the asexual method it matures and propagates within the human host. By the other in order to attain maturity after having partially developed in man it enters a second host—a certain species of mosquito. This sexual cycle ensures perpetuation of the parasite, as it is by this means only that the parasite can pass from man to man. An infected anpoheline while

feeding on human blood introduces into the red blood-cell the infecting sporozoites of the sexual cycle. These grow at the expense of the hæmoglobin, become pigmented

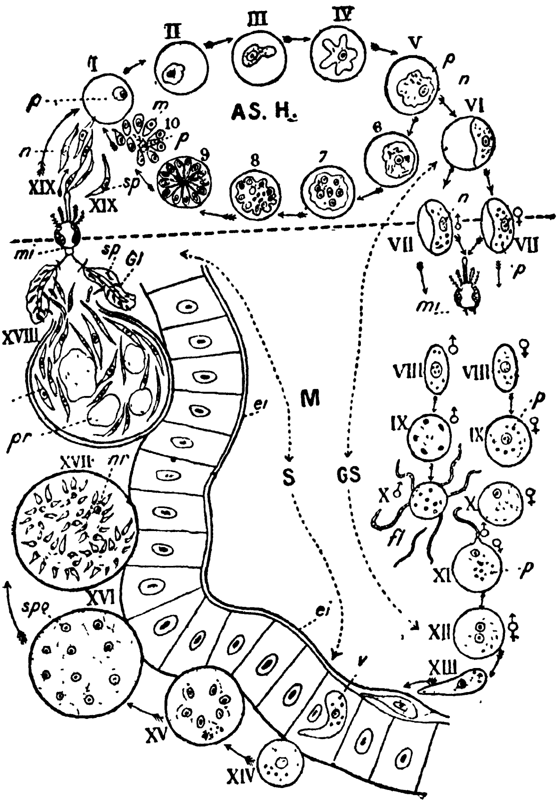

FIG. 90.—THE MOSQUITO CYCLE.

AS. H, Cycle occurs in the patient's blood ; The portion below the dotted line shows the sexual cycle in the body of the anopheles. VII, cresent bodies which enter, at the time of biting, the body of the mosquito. XII, a zygote with two nuclei (male & female) ; XII, ookinet, which passes through the stomach wall of the mosquito ; XVIII, oocyst after rupture of the wall ; sp, sporozoites reach the salivary glands, Gl ;

and when mature develop either into *Schizonts* (Schizogony), or into *Gametocytes* (Sporogony).

The Asexual or Human Phase.—The schizonts arrange themselves into minute segments or merozoites when the enveloping blood corpuscle breaks and these merozoites escape and become free in the plasma. The phagocytes however absorb many of the merozoites, but some escape, attack fresh red-blood cells and start the cycle anew, thus completing the endogenous cycle and perpetuating the parasite in the vertebrate host.

The Sexual or Mosquito Cycle (*Sporogony*).—The sexual or exogenous cycle is passed in the bodies of the particular species of mosquitoes. The gametes or gametocytes develop into two kinds, male and female. The male one emits several microgametes (flagella), one of which impregnates the female gamete. It then acquires locomotive powers and becomes an ookinet and burrows into the stomach wall of the mosquito where it grows and becomes surrounded with a capsule, when it is known as an *oocyst.* This becomes packed with minute bodies or sporozoites. With the rupture of the oocyst the sporozoites escape and find their way into the salivary glands of the mosquito, whence, opportunity offering, they reach human beings. These spores then attack the red blood-cells become schizonts and begin the cycle again. If the patient is now bitten by a mosquito it will abstract the parasite, which passes into its stomach and the true sexual life then begins.

In the absence of sexual reproduction the parasites after some time die out owing to the exhaustion of the reproductive power. This is what happens when the patient is given quinine and the young ones which would eventually have given rise to sexual forms are destroyed.

Estimation of Malaria.—From the point of view of prevention this is necessary as it gives an idea of the incidence of the disease in a particular place. Different methods have been used for the purpose, but each one is open to certain objections. One method is to base the estimation on the *statistics* of the cases. This is useful only where a relatively small proportion of the population is

affected and where the diagnosis can be relied upon. This however gives only the incidence of cases that go to the hospital or attend dispensaries. For practical purposes the data so obtained are not of much value and scarcely help in the study of endemic malaria. The second method is to examine the blood of indigenous children and the percentage showing the parasite is known as the *endemic or parasitic index.* This method of estimation is open to certain objections. It is obvious that the number of infected children will depend upon the time given by each observer in the examination of each child. It is possible that some of the infected ones may have few parasites, and one cannot be absolutely certain even after a careful examination that an apparently un-infected person is really so. Another method is by the *splenic index.* This was first used by Dempster to measure malaria in the Western Jumna Canal District. It gives the percentage of children in whom the spleen can be felt, and has the advantage of being easy and rapid in determination. The size of the spleen is also recorded in this examination. This is done by recording the degree of enlargement in so-called finger breadths. Those which just passed beyond the costal margin are termed one finger-breadth ; those more than an inch or so are two finger-breadth. The last method of estimating malaria is by finding out the *sporozoite index.* This is determined by dissecting anophelines caught in the infected area and finding out the percentage showing sporozoites in the glands. In a very malarious place this index may be 5 to 10 p.c.

Prevention.—In no disease is it more true that prevention is better than cure than in the case of malaria, for, although it is easy to cut short an attack yet it is difficult completely to eradicate the infection from the system (Rogers). From what has been said with regard to the ætiology of malaria it is reasonable to make the following deductions :—

1. Were all mosquitoes exterminated malaria would cease.

2. Were all persons protected against the bites of mosquitoes no malarial infection would arise.

3. Were all existing cases of malarial infection cured then malarial disease would be exterminated.

As corollaries to these Hehir draws the following conclusions :

1. If mosquitoes can be diminished or prevented from attacking man the chances of dissemination of malaria can be reduced.

2. If cases of malarial infection are lessened in number the chances of communicating the disease from man to man by anophelines are reduced.

The basis of malaria prophylaxis depends upon the fact that particular species of mosquitoes are indispensable for the propagation of parasites, and that in nature the parasites occur in both hosts, viz. man and mosquito, and so far as is known nowhere else. Preventive measures are therefore founded on these facts, and have for their object (1) the destruction of the insect host, (2) the prevention of the transference of the parasites from one host to another, and (3) the destruction of the parasites in the blood of man. Prophylaxis may be considered under the following heads :

A. Protection against mosquitoes by
- (*a*) mosquito-proof houses
- (*b*) personal protection
  - (i) mosquito nets,
  - (ii) punkahs and fans,
  - (iii) mosquito-proof clothes,
  - (iv) culicides.
  - (v) culifuges.

B. Attack on mosquitoes and their larvæ
- (*a*) Permanent measures
- (*b*) Annual measures
- (*c*) Larvicides
  - (i) use of chemicals,
  - (ii) cultivation of fish,
  - (iii) dragon-fly larvæ,
  - (iv) frogs, lizards, spiders, etc.

C. Quinine
- (*a*) For the eradication from population
- (*b*) Prophylaxis

D. Prophylaxis in villages

A. Protection against Mosquitoes.

The greater part of prophylaxis against malaria is embraced in protecting human beings from mosquito bites. The measures adopted are :

(*a*) *Mosquito-proof Houses.*—Protection of the whole house or parts of the house with fine wire gauze was extensively used during the last war especially in the most malarious parts of Salonika, and there was ample evidence of great reduction in the number of the mosquitoes.

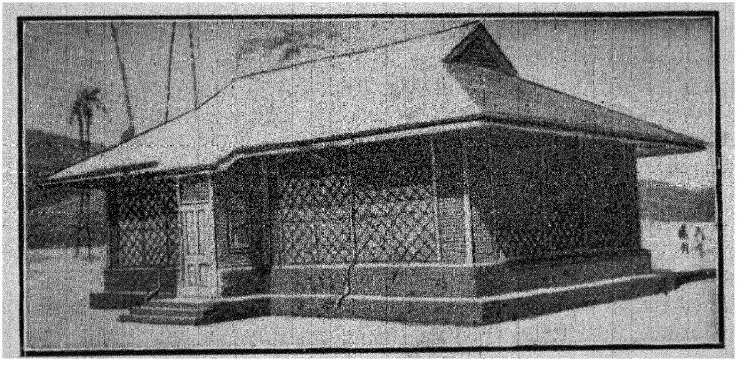

FIG. 91.—MOSQUITO-PROOF AND STORM-PROOF HOUSE.
(From Annals of Tropical Medicine and Parasitology).

This appears to be an ideal method of excluding mosquitoes, but the cost is rather prohibitive, and cannot be used universally. This is after all a mechanical protection and the occupant is open to infection as soon as he comes out of the house. In the absence of actual mosquito-proof houses, the doors and windows may profitably be kept closed in India by *mulmul* and door *chicks* which should be kept carefully closed all day.

(*b*) *Personal Protection* :

(i) *Mosquito netting.*—As early as 1828 Annesley recommended the use of the mosquito net as a protection against malaria. A mosquito net is of most practical value and according to Ross the zealous use of a net

reduces the chances of infection anywhere by 90 per cent. Mosquito nets are fairly cheap, and may with advantage be used by all classes. Head nets made of muslin draped in metal or cane rings of wide circumference, gloves or gauntlets of finely woven cotton material ; large, roomy, long and capable of being fastened down were found to give some protection to the troops, and may be used while visiting malaria infected places.

(ii) *Punkhas and fans* are useful in driving away mosquitoes.

(iii) *Mosquito-proof Clothes.*—Suitable clothing often affords protection against bites. Since mosquitoes can bite through thin cotton garments, it is advisable to use thick woollen garments especially during the malarial season.

(iv) *Culicides* are agents used to kill mosquitoes. Various fumes, gases, and odours kill adult mosquitoes, and of these sulphur fumes, formaldehyde vapour, smoke of the leaves of *neem* (*Azadirachta indica*), crysanthemum and pyrethrum powder, and of odours—menthol, camphor, turpentine, *loban* (benzoin), etc., are generally used. Cresyl has been recommended as a good fumigant. The quantity required being 75 grs. per every 35 cft. of space and need only be left to volatilise in the closed room. The simplest way to keep away mosquitoes is to make a smoke by burning cowdung cakes in the house. This is generally done in cattle-sheds in India.

(v) *Culifuges* are agents that prevent the bites of mosquitoes. Oil of eucalyptus, oil of rosemary, lemon grass oil and essential oils generally, are used to keep off mosquitoes, and they are commonly applied to the skin of the face, hands, ankles, and other exposed parts of the body. Kerosene oil applied with lanoline, or pure oil sprinkled about the bedroom also keep off mosquitoes. These have no value as an antimalarial measure of such certainty as to warrant their extensive use.

Certain colours like navy blue, dark red, reddish brown, and black are attractive to mosquitoes.

B. Attack on the Mosquitoes and their Larvæ.

(*a*) *Permanent Measures.*—The most important and effective way of getting rid of mosquito is by the conver-

sion of real or potential breeding places into impossible or unlikely breeding places. This includes removal of any small collection of water in old tins, bottles, rain water puddles, etc. Vessels used for storing rain water in houses should be kept covered and should be emptied atleast once a week. Rain water barrels, reserve tanks, etc., should be effectively screened, oiled or stocked with small fish specially known to prey on mosquito larvæ. Being the most easy and economical way, marshes, swamps, *jheels*, etc., should be drained into some water-course.

An efficient method of stamping out malaria from Bengal is the adoption of a comprehensive scheme of *irrigation* from the main rivers. Any well-planned scheme of irrigation will reduce malaria by preventing the growth of mosquitoes and at the same time increase the productive power of the land by depositing silt. In Italy, Holland, Belgium and elsewhere malaria has been brought under effective control and eradicated by a like method.

When earth is dug out for constructing huts and other houses in villages these hollows form sandpits or claypits. This practice should be discouraged when done at random. The best plan is to reserve a plot of land for the purpose which in time may be converted into a decent tank if properly managed.

(*b*) *Annual Measures.*—When marshes or other collections of water cannot be dealt with permanently by drainage or other means and for small operations, annual measures may be of great value in some districts. These are best performed by what are called "mosquito brigades." They may usefully be applied to a great variety of places in India—towns, collections of villages, cantonments, jails, and all large industrial works and factories. Considering the fact that the aggregation of large gangs of labourers on engineering works, famine relief works, railway constructions, irrigation canal works, road-making, etc., often helps in the formation of breeding-grounds of anophelines, one would emphasise the necessity of their employment under such conditions. Half a dozen labourers under one headman and a few gangs of such

men working efficiently can do much to prevent malaria. The duties of mosquito brigade men are :—*

(1) To visit regularly once a week the compound of every house and destroy every pool of water which can harbour mosquito larvæ : (2) to cover with a layer of kerosene oil and pesterine every collection of water which is too large to be destroyed : (3) to remove all broken tins, pots, bottles, etc., which can contain water and harbour larvæ : (4) to instruct the inhabitants in the recognition of mosquito larvæ and in the methods of destroying them : (5) to see that by-laws requiring all fixed receptacles of water, cesspools, etc., to be made mosquito-proof, are carried out, and to bring to the notice of the superintendent any householder in whose premises mosquito larvæ are frequently found : (6) during the rains to drain off quickly all superficial collections of water which can last sufficiently long enough to become breeding-grounds of mosquitoes : (7) to endeavour to kill adult mosquitoes in houses, out-houses, and stables by fumigation with sulphur and other means : (8) to make observations as to the seasonal prevalence of mosquitoes, their habits, and every matter regarding which increased knowledge might aid in the extermination of these insects.

The best time for carrying on antimalarial measures is in the months of September and October, *i.e.*, after the rains are over. All rank vegetations (jungles) near the house should be cut down as they afford shelter to the mosquitoes during the day. It has been observed in the Federated Malay State that if jungles to a distance of about half a mile from an inhabited area or village are cut down the incidence of malaria is considerably reduced.

(*c*) *Larvicides* :

(i) *Chemicals*.—Petroleum and all oils act by intercepting the air from the larvæ requiring oxygen. The stratum of oil prevents inhalation of air by the larvæ and by obstructing the breathing tubes causes them to be asphyxiated.

Kerosene diffuses more readily. About two ounces of oil is used for every 30 sq. ft. The emulsion should always

* Major James, *Malarial Fevers ;* Third Edition.

be preferred to the oil as it diffuses more readily, and forms a uniform film over the surface of the water. It is prepared by dissolving 3 parts of common soap in 15 of boiling water and then adding 82 parts of kerosene oil with constant stirring. Only sprinkle the emulsion over the water or on the edge of the tank. The treatment should be repeated once a week. Its use should be restricted to stagnant pools or any collection of water which cannot be drained. The application is best done by means of an ordinary garden spray. *Pesterine* is crude petroleum sold in four-gallon tins.

The application of chemicals like kerosene oil and crude petroleum is not always followed by the extermination of the mosquito larvæ. In order to be effective it has to be repeated very often, and, besides being a nuisance, the material is apt to be washed away after a heavy shower. Being poisonous, the application kills the small fish, snails, and other animals by nature inimical to mosquito larvæ. In fact it does more harm than good. In villages where men and cattle use any collection of water for drinking purposes, to scatter poison broadcast is not unattended with some danger.

(ii) *Cultivation of Fish.*—It has been suggested that the existence of "millions" around the islands of Bermuda and Barbados is the cause of the absence of malaria and mosquitoes in those places, and "Barbados millions" were imported for the purpose of checking malaria in India. The result was, however, disappointing, and it has been pointed out that the indigenous fish, *Haplochilus panchax*, is superior to the foreign species in battling with the mosquito larvæ. Haplochilus is not only more active and agile but more hardy than millions, and bulk for bulk can clear a great deal more of living larvæ than the millions. They fare well in shallow water, prosper and multiply by the edges of the tanks in among the weeds. The following are some of the varieties :—*

Genus.	Species.	Local Name.
Haplochilus	H. panchax	*Panchoke, Lal jhingra*
Do.	H. uncolatus	*Pihu.*

* Swell and Chaudhuri, *Indian Fish of Proved Utility as Mosquito Destroyer.*

Trichogaster	T. fasciatus	*Khalse, Khalas.*
Badis	B. badis	*Chiri, Bhedo.*
Anabas	A. scandens	*Koi, Kavoi.*
	Chela agentea	*Chilwa.*

The fishes selected should have the following characters :—

1. They should be small in size.
2. They should be hardy and should flourish both in shallow and deep waters.
3. They should breed freely in confined water areas.
4. They should be able to stand transport and handling.
5. They should be able to escape all natural enemies including artificial contrivances of men to catch them.
6. They should be absolutely worthless and insignificant as food.
7. They should not be a danger to the indigenous fish population.

Dragon fly larvæ and tadpoles also destroy mosquito larvæ. Bats, lizards, spiders, etc., are the enemies of adult mosquitoes.

C. Quinine.—The last war has emphasised the importance of adequate prophylactic treatment of malaria, and has once more brought into prominence the vexed question as to which is the best derivative to thoroughly treat malaria and prevent its relapse. To realise the importance of this question it is only necessary to remember that the greatest loss of effective man power particularly on the Eastern fronts was due to malaria.

Quinine has been used in the treatment of malaria and acts by destroying the parasites in the circulation. The following points have to be taken into consideration with regard to the administration of quinine in malaria : (1) Its proper dose. (2) Time for administration. (3) The best salt of quinine, and the most soluble method of administration. (4) The best method for using it for prophylactic purposes. (5) The class of cases in which the use of quinine is inadmissible.

The principle aimed at in cinchonisation of the inhabitants of a malarial district is the extinction of malarial

parasites in all infected persons ; but complete eradication of malaria from the human system by quinine takes a longer time than is ordinarily followed. " To extirpate the parasite in a patient demands, let us say, four months assiduous cinchonisation, and in very malarious towns a large percentage of the natives and nearly all the children may be infected. To deal with these will require a heavy annual expenditure for medical attendants and quinine with examination of immigrants." The actual expenses incurred for anti-malarial operation in the town of Dinajpur (Bengal) was annas four per head of population. This included the cost of quinine as also the medical attendance. The actual cost of quinine used was about annas two and pies six only per head per annum (Bentley).

Apart from the prophylactic use of the quinine it is necessary that every one suffering from malaria should be effectively and cheaply treated. In quinine and cinchona febrifuge we have valuable agents for the treatment of malaria. Cinchona febrifuge has the advantage of being the cheapest and thus can be utilised extensively for mass treatment. Provided it is given after food one need not apprehend any gastro-intestinal trouble.

As a prophylactic there are various methods of administering quinine but it should always be given regularly. The best form is to take five grains every day (preferably in the evening) during the malarial season. The prophylactic use of quinine is now adopted practically in all jails and among all troops. Europeans living in endemic malarial districts should take quinine regularly as a prophylactic ; but for the use of the general population certain difficulties are met with :

1. A very large number of patients have a strong prejudice against quinine.

2. Public generally regard a medicine as something to be taken only when ill. They do not believe in prophylaxis and it is often impossible to persuade them to take medicine for that purpose.

3. It is extremely difficult to administer quinine to children, who are the chief disseminators of malaria.

Therefore, for quinine prophylaxis to be successful in any given area four things have to be accomplished :

1. Remove the prejudices of the public against quinine.
2. Impress the idea that prevention is better than cure.
3. Use some palatable form of quinine for administration to children. Euquinine or tannate of quinine are comparatively tasteless.
4. It must be given so as to be quickly absorbed by the stomach, otherwise there will be failure. The best form of administration is in solution.

D. Prophylaxis in Villages.—*See* Village Sanitation.

Kala-azar

Manson describes kala-azar as an infective disease characterised by chronicity, irregular fever, enlargement of the spleen and often of the liver, the presence of the "Leishman body" in these and other organs, emaciation, anæmia, frequently a peculiar hyper-pigmentation of the skin, and a high mortality.

Under the name of Burdwan fever the disease was known in Lower Bengal in the early 'fifties of the last century, and it was known to exist in Assam from as far back as 1869. In 1881 it broke out in an epidemic form at the foot of the hills just to the east of the Bramhaputra. The earliest record of the disease is by Clarke who in the Assam Sanitary Report for 1882 described it as a severe form of malarial cachexia.

Ætiology.—In 1903 Sir William Leishman first described the parasite of kala-azar, and about the same time Donovan observed similar bodies in the spleen of patients dying of chronic fever in Madras. These parasites have been named after them and are known as "Leishman-Donovan bodies." They are small round or oval bodies about the size of a blood plate. In each parasite an oval macro-and a rod shaped micro-nucleus and a capsule can be differentiated. Most of the parasites are free and a few are aggregated inside leucocytes. The distribution of the parasites in the body is rather general, but they are most numerous in the spleen, bone-marrow and liver. They

also occur in the blood though in small numbers, being found there both in polymorpho-nuclear and mononuclear leucocytes, and very rarely in the red corpuscles. In the blood they are in greatest abundance towards the termination of the case, especially during fever, and when intestinal symptoms are present (Donovan). Rogers discovered the flagellated stage of the parasite suggesting that the organism belongs to the genus Herpetomonas.

The disease spreads by human intercourse, and unlike malaria it shows a predilection for the acclimatised ; the natives of the place and the old residents are said to suffer most. Both sexes and all ages are equally affected and no occupation is a bar to the disease. The majority of cases occur during the cold season.

The disease is on the increase in Bengal, and is very common in Calcutta and seems to attack all classes. It is not so common, however, with the upper-class Europeans.

Mode of Transmission.—This is still doubtful although there is evidence that in the Mediterranean coasts the dog is the principal reservoir of the disease, and that the dog fleas—*Pulex serraticeps* and *Ctenocephalus canis* are the transmitters. The fact of several cases occuring in the same family or house suggests mode of transmission through animals or insects domestic in their habits.

Notwithstanding a large amount of work the mode of infection is still uncertain ; although Patton still maintains the bed-bug theory. Others, however, seem to believe that the parasite may leave the human body either by the alimentary canal or through the agency of blood-sucking insect. It is however very doubtful if the parasite ever escapes in the fæces. Of the different possible blood-sucking insects mosquitoes, lice, fleas and ticks may be excluded on various epidemiological and experimental grounds. Mackie suspects the sand-fly and thinks that the *Herpetomonas phlebotomi* is worthy of further research. While the Indian *Conorhinus* is considered responsible as the intermediary host by others.

Prophylaxis.—It is now certain that this awful scourge can be robbed of most of its terrors whenever it is possible fully to carry out segregation measures. This isolation should be followed by thorough disinfection of infected clothes, houses, beddings, fomites. Destruction of all forms of insects, especially bed-bugs, in infected houses is the only important measure in the present state of our knowledge.

Enteric Fever

Enteric fever is widely distributed all over the world, particularly in India. It is more common among Europeans, especially among new comers.

Ætiology.—The disease is caused by a specific micro-organism called the Eberth-Gaffky bacillus. It is a short, thick, flagellated, motile bacillus with rounded ends and in appearance not unlike the tubercle bacillus. It can be isolated in autopsy from the spleen, mesenteric glands, and gall-bladder.

Mode of Infection.—The great source of danger lies in the fæces and urine of the typhoid patients. The infection may be *direct* or *indirect.*

(*a*) *Directly* it is communicated to the attendants for want of proper precautions in handling patients or their excreta. Infection sometimes clings to the bed of the typhoid patient, and successive patients seem to get the attack when occupying the same bed.

(*b*) *Indirectly* it is communicated through water infection. Many widespread epidemics are traced to this cause. The water of tanks or wells, once polluted, will spread the disease which becomes a scourge to the locality. It is essentially a food-borne disease, and in India the chief source of infection is through contaminated milk and water.

Milk very often contains typhoid bacilli when mixed with polluted tank or well water. The disease may also be transmitted by salads, ice-cream, etc., or by eating celery or uncooked vegetables which have grown on soil on which infected materials have been used as fertilisers.

Flies alternately visiting and feeding on infected fæcal matter and on food are also a great source of danger.

Typhoid bacilli can be discovered in the urine and stools of persons who have suffered from the disease for a considerable time after recovery. These carriers are a great source of danger (*See* page 334).

Season.—In temperate climates the disease is more prevalent in autumn and early winter. In India the disease is equally prevalent all the year round, and in Bengal it shows its maximum in the dry hot months. The majority of cases among Europeans here occur in the dry cold and hot seasons.

Age, Sex, etc.—Both sexes and all classes and races are equally affected. Typhoid among Europeans born and bred in the tropics is four times more prevalent amongst children under fifteen and four times less among adults over twenty-five, as compared with temperate climates. But those who are exposed to infection do not always take the disease. Some families are more susceptible than others. It is said that one attack gives immunity, although two attacks within a year have also been recorded. Within a short time after recovery the immune substances disappear from the blood, but the relative immunity lasts for a long time, frequently for life.

Prevention.—An early diagnosis of the case followed by isolation or segregation of the sick. Stools, urine and other discharges should be received in vessels containing strong disinfectants, and should either be deeply trenched or cremated along with soiled rags, etc. Soiled clothes should be placed in a strong solution of carbolic acid and then boiled. Rigid methods of cleanliness by attendants should be adhered to.

It is almost impossible to lay down any rules for the management of the carriers excepting isolation, cleanliness, disinfection of stools and urine, and selection of employment which gives no opportunity of infecting other people. There is no safe and reliable method by which a carrier can be freed from infection.

In all outbreaks of typhoid the existence of the antecedent cases ought to be enquired into. The sanitary

conditions should be carefully investigated, especially in relation to the house. The milk-supply requires thorough investigation, and this gives most trouble ; since one has to consider the possible risks not only during storage and distribution, but also the possibility of contamination from infected water. Individual prophylaxis depends upon boiling all water for drinking purposes, protecting all food from flies and dust ; disinfecting hands with some strong antiseptic lotion after nursing, and paying special attention to the condition of the stomach and intestines.

Protective Inoculation.—As a protective inoculation against typhoid fever a vaccine was first prepared by Wright and Semple at Netley in 1896. This vaccine resembles Haffkine's anti-plague prophylactic in that it contains dead typhoid bacilli and their toxins. The bacilli are grown in bouillon under strict aseptic conditions. The initial dose consists of 500 to 1000 millions, the second of double the quantity.

Two inoculations are made at an interval of ten days. There is generally some reaction after the first dose, which consists of a certain amount of febrile disturbance with headache and general aching. There may also be a slight local reaction, with swelling of the glands which lasts for a day or two. The experiences of the great European war testify to its high value as a prophylaxis beyond all doubt. According to Wright's statistics the case incidence amongst the inoculated was only 2.25 per cent. with a mortality of 12 per cent. against 5.75 per cent. and 21 per cent. respectively amongst the unionoculated.

Plague

Plague is an acute infectious disease caused by a specific bacillus and characterised by inflammation of the lymphatic glands, sometimes by pneumonia or septicæmia.

The earliest historical record of plague is by Rufus, of Ephesus, describing a fatal form of bubo which occurred in Lybia, Egypt, and Syria about the third and the beginning of the second century B.C. The first authentic account of

plague refers to the latter half of the sixth century A.D., which lasted for fifty to sixty years and was known as the plague of Justinian. From that time there was no other epidemic till the Black Death of the fourteenth century. In the fifteenth century there were outbreaks in many parts of Europe, chiefly imported from the East. The first outbreak of plague recorded in India was in 1612 by the Emperor Jahangir. In 1815 bubonic plague broke out in Kutch, and then spread to Sindh and Guzerat, and lasted till 1821. In 1823 it broke out in the Kumaon Hills on the west of Nepal, and was known as *Mahamari*. In 1836 a fresh outbreak occurred in the town of Pali in Rajputana, spreading to Jodhpur and Marwar, and continued till 1838. This is known as the Pali plague.

In 1871 plague appeared in an endemic form in the south-west of China in the province of Yunan, and, probably following the trade route, it spread to Pakoi on the Gulf of Tonquin. In February 1894 it had extended to Canton, and in April it appeared in Hong-Kong and many other places in the southern provinces of the Chinse Empire.

In 1896 it broke out in Bombay, having probably been imported from Hong-Kong, and thence it spread to Calcutta, and subsequently throughout India. The total number of deaths recorded from this cause in India for thirteen years (1897-1909) amounted to 6,133,476. In 1918-19 the mortality from plague in India sank to less than one sixth of the mean mortality during the past twenty years.

Six varieties of plague are commonly met with ; they are bubonic, pneumonic, septicæmic, intestinal, pestis ambulans, and pestis minor. Of these the bubonic and the pneumonic forms are most common.

The Bacillus.—The plague bacillus was first discovered by Yersin and Kitasato during the Hong-Kong outbreak in 1894. It is a short oval bacillus with rounded or square-cut ends occurring singly or in dumb-bells, and occasionally in chains ; it is non-motile and does not form spores. The bacilli are demonstrated from post-mortem specimens or from puncture of infected glands.

The bacillus is killed by heating for ten minutes at 62° to 65° C. and loses its virulence on drying. The bacillus is readily destroyed by antiseptics ; a 1 in 1000 corrosive sublimate or 1 in 100 chloride of lime solution being efficient. The German Plague Commission stated that the longest time the bacilli of infected materials remained active was eight days. In drinking water they die in three days, and in sterile water in eight days. Direct sunlight kills the organisms in three to four hours.

It is also present in great abundance in the spleen, intestines, lungs, kidneys, liver, and other viscera, and also, though in small numbers, in the blood. In the pneumonic type it is present in the sputum in enormous numbers.

In addition to man, monkey, cat, rat, mouse, guinea-pig, and rabbit are also susceptible to inoculation.

Modes of Entry.—Plague may enter the body in three ways, viz., by (1) inoculation, (2) inhalation, and (3) ingestion.

1. *Inoculation.*—This is the most common mode of entry. It is not necessary that the insect (rat flea) should inject the poison into the puncture every time it bites, but it is probable that infection may enter through the bite, either by being already on the skin when the insect bites, or by subsequent contamination of the wound. The irritation may produce scratching, which may be done with an infected finger, and thus inoculation may occur. The flea feeds on the infected rat and accumulates a large mass of *B. pestis* which causes partial obstruction and when it bites man part of it is regurgitated from the stomach and infects the victim. Some of the bacilli are expelled with the fæces and may infect through scratching or any existing abrasion.

2. *Inhalation.*—This is the mode of entry of pneumonic and sometimes of septicæmic plague. Kitasato has demonstrated the presence of *Bacillus pestis* in the dust from the walls of a room occupied by a plague patient. It appears that this mode of infection is common in India, where the plague-infected houses are generally ill-ventilated, dark, and densely crowded.

3. *Ingestion* —Feeding experiments on animals with tissues of plague patients and on cultures of the specific bacillus have shown that the disease may be communicated by this channel through infected food and drink. The bacillus is said to have been found in the intestinal contents and urine of patients. Food contaminated with sewage and fæcal matter or by infected rats may therefore be regarded as a possible medium of infection.

The Rat.—Although small and circumscribed epidemics of plague may possibly occur without the intervention of rats, it is definitely proved that in most epidemics of bubonic plague the rat plays an important part in the propagation of the disease.

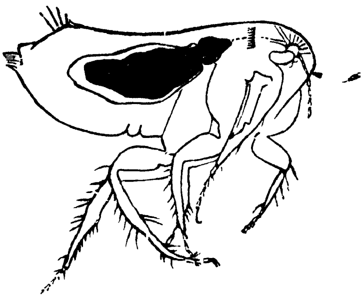

FIG. 92.—Flea viewed as a transparent object. The proventriculus and stomach contain a mass of plague culture. (Manson).

The disease is essentially a rat disease and is carried to human beings by fleas which have fed on infected rats. The rats chiefly responsible are the black domestic rat (*Rattus rattus*) and the brown rat *Rattus* (*Decuminus*) *norvegicus*, the common water rat or sewer rat. The plague usually occurs first in the *Rattus norvegicus*, then in the *Rattus rattus*, and subsequently in the man. These rats are usually infected with fleas, chiefly *Xenopsylla cheopis*, and *Ceratophillus fasciatus*

Rattus rattus, is the common domestic animal in India, and lives and breeds in and about human dwellings. It is the black rat and feeds upon grain and other articles of food stored in the house. It is distinguished from *Rattus norvegicus*, the brown rat, by its tail being longer than the body and large ears. It has a small and pointed head, a smooth coat, and is comparatively small. The black rat does not migrate to any distance. When

the infection is present and the rat population sufficiently numerous to maintain an epidemic, an epizootic (or precedent outbreak of the disease in animals) takes place. If the rat population is scanty, the epidemic either cannot arise or is of short duration. The epizootic among rats is followed after an interval of about a fortnight by the outbreak of human plague.

The plague infected flea may live apart from the rat host, and remain infected for a period of 23 days, and in low temperature even longer. In a hot dry climate say 80° F. the infected fleas die, the probable cause of cessation of plague in hot season. In certain parts of India the climatic conditions are such, that given a sufficient quantity of black rats to maintain the infection, the disease may persist throughout these months which in other parts of the country are non-epidemic. Moreover, in any part of India, plague may persist among rats through non-epidemic season without revealing its presence by unusual sickness and mortality. The prevalence of rat flea is intimately associated with the season of the year. They wildly multiply and are very active when the temperature is 50° F. or thereabout. The average life of the flea apart from its host has been found to be about ten days in Mesopotamia, while in tropical temperature it can harbour the bacillus when feeding on blood for forty five days.

Means of Spread.—Plague is chiefly spread by contact directly with persons suffering from the disease, or with materials infected by such persons, or plague-stricken rats. The conclusions of the Indian Plague Commission may be quoted *in extenso* :

1. Pneumonic plague is highly contagious. It is, however, rare (less than 3 per cent. of all cases) and plays a very small part in the general spread of the disease.

2. Bubonic plague in man is entirely dependent on the disease in the rat.

3. The infection is conveyed from rat to rat and from rat to man solely by means of the rat flea.

4. A case of bubonic plague in man is not in itself infectious.

5. A large majority of plague cases occur singly in houses ; when more than one case occurs in a house the attacks are generally nearly simultaneous.

6. Plague is usually conveyed from place to place by imported rat fleas which are carried by people on their persons or in their baggage. The human agent himself not infrequently escapes infection.

7. Insanitary conditions have no relation to the occurrence of plague except in so far that they favour infestation by rats.

8. The non-epidemic season is bridged over by acute plague in the rat, accompanied by a few cases amongst human beings.

The Commission has further shown that an epizootic of rat plague may start without contact or even proximity of healthy and infected animals. As long as fleas from an infected animal are transferred on to a healthy animal they will cause infection. It is evident from the findings of the Plague Commission that the chief agents in the development and perpetuation of plague epidemics are the rats and the rat fleas (*Xenopsylla cheopis*) and other species of fleas, such as *Ctenocephalus canis*, which also bite dog, rat, and man.

Recent researches have demonstrated that the rat flea can be transferred through grain and in grain sacks. This fact was responsible for cases of plague in ships which were free from rats but carrying grains from Basra to Amara and Baghdad.

Owing to the free discharge of the organism with the sputum and the consequent direct infectivity at short ranges of the disease, *pneumonic plague* spreads from man to man directly. The recent epidemics in Manchuria were of pneumonic variety. Pneumonic plague is more liable to occur in temperate and cool seasons. As it does not lead to an infection of other animals or an epizootic, the epidemic has a tendency to die out rapidly.

Conditions favouring Plague.—Sir Thomas Fraser, the President of the Indian Plague Commission, holds that the most potent factors predisposing to an outbreak of plague

are overcrowding and insanitary conditions. But these alone are not sufficient, for even in the filthiest and most over-crowded areas after an outbreak the plague dies out spontaneously. Insanitary conditions may be regarded only as a predisposing factor. Soil does not appear to harbour the germs. The Indian Plague Commission noted that the bacillus had not been recovered from the soil by any trustworthy observer.

The universal experience of plague in India proves that houses into which the infection of plague has been imported whether by man or rats are infective ; this infectivity being so marked that many of the officers who have had most experience of the disease have come to the conclusion that the principal source of the infection is to be found in the house into which the infection of plague has been introduced. Plague is worse in towns where rats get plenty of food, and the chief centres for plague are those areas where grains, such as dal, rice, etc., are stored.

The *Bacillus pestis* has not been recovered from the mud or cowdung floors in India. The Plague Commission has shown that floors of cowdung if contaminated with *Bacillus pestis* do not remain very infective for more than forty-eight hours, and that floors of *chunam* cease to be infective in twenty-four hours.

Seasonal Prevalence.—Although it appears that season has some influence on the epidemicity of plague yet an epidemic may occur under any climatic condition. The first Bombay epidemic (1896) was at its highest in December, the second reached its highest in February, and the third in March. In Calcutta and Karachi epidemics occur during the hottest season, and in Poona during the monsoon. The plague however constitutes a notable example of seasonal disease. its intensity being at its lowest ebb in July, gradually increasing till it reaches the zenith in March and rapidly declining during the next four months.

Prevention.—The preventive measures may be considered under the following heads, viz.—

1. Evacuation of the infected area, and special hospital for the treatment of the sick.

2. Campaign against rats.
3. Antiplague inoculation.

A. *Evacuation of the infected area.*—As soon as the disease is recognised the sick should be isolated from the healthy, and infected clothes, articles and houses should be thoroughly disinfected. All insanitary conditions should be attended to and overcrowding prevented. Examination of passengers leaving the infected areas either by rail or steamer should be enforced. If practicable the infected village or locality should be evacuated and the inhabitants accommodated in temporarily built quarters or huts, while the infected ones and those adjacent to them should be thoroughly disinfected. In cities evacuation is rather difficult, when enforced it has sometimes met with serious opposition, and therefore requires careful control and organisation. Voluntary evacuation, when uncontrolled, has too often taken the form of a stampede which carries the disease to the uninfected area.

These measures have however not proved a success. But if fully organised by (*a*) the institution of infectious diseases hospitals ; (*b*) organised preparation of camps for evacuation of the infected quarters ; (*c*) the multiplication of the rural dispensaries ; and (*d*) a great increase in the rural area of the number of medical men capable of instructing the public with the benefit of sanitary measures, and giving preventive inoculations, it will then yield more satisfactory results.

B. *Campaign against Rats.*—In cases of outbreaks it is important that one should remember the following points :

1. That an intimate relation exists between rat plague and human plague.
2. That when conveyed to man it is communicable to others and to rats by means of expectoration, excreta, and discharges from the buboes and other glandular swellings.
3. That rat plague precedes human plague.

It follows, therefore, that the prevalence of plague depends on the density of the rat population.

(*a*) ***Rat elimination or the prevention of rat infestation.***—This comprises such modifications in the habits, customs

and dwellings of a community as will result in a diminished rat infestation in the homes of the people and make the association between rats and men less intimate than at present.

(*b*) Measures designed to protect the rat population of any given town or village from plague infection.

(*c*) Rat destruction designed, as in (*a*), to diminish the chances of infection, and to keep the rat population at so low a level that, if plague be introduced, the severity of the resulting epidemic will be appreciably diminished.

(*d*) If efforts under these three heads fail to keep plague out, it is left to try and render the human population immune to attacks of the disease by means of inoculation, or to remove the population at risk from close association with infected rats. The latter involves the evacuation of infested dwellings and the provision of temporary accommodation outside the rat-infested or plague-infected area.

I. Rat Elimination

A full knowledge of the habits and customs of the rats is essential to the successful prosecution of anti-plague measures.

1. *The rat.*—The common Indian house rat, *Mus rattus*, is a very domesticated animal and is rarely found far from human habitation. For shelter it seeks the darkest corners of the dwellings, especially if such offer facilities for burrowing and a convenient supply of food. The rat possesses remarkable powers of climbing, and the ordinary *kutcha* mud wall offers no difficulties. A hard, smooth vertical surface free from irregularities and projections is not easily surmounted. A water-pipe or a drain-pipe, which can be grasped by the rat's legs and tail, is easily climbed. A ledge, projecting horizontally 9 inches or more from the wall, if quite smooth and hard on the under surface, presents an insurmountable obstacle. A rat may succeed in jumping on to a ledge two and a half feet high, but not one three feet high.

Grain is the natural food of *Mus rattus*, which is very largely vegetarian in its habits : in certain circumstances

the house rats will devour "meat," or even the dead bodies of other rats, but uncooked grain is their chief article of diet. Usually the rat favours that variety of grain which forms the staple food of the human population among which it dwells. Thus the rats of Poona prefer *bajri* to anything else ; the rats of Madras are rice-eaters ; the rats of Sholapur affect an equal preference for *jowari* and *bajri*. Finally rats must have water if their food be dry ; sufficient water is obtainable from fresh, or wet, vegetables or grass.

A rat becomes sexually mature at a little over two months ; the most common number of young at a litter is five. The sexes closely approximate each other in number. So prolific are rats that, given sufficient food and shelter, a pair of rats may become 80 pairs in the course of a year.

2. ***Rat** elimination.*—Energetic and sustained rat-destruction campaigns will do much towards keeping the rat population at a low level with a consequent markedly diminished risk of plague-infection and the certainty of much milder epidemic. Such measures necessitate sustained effort. Moreover, rat-destruction campaigns are of only temporary benefit, and it is necessary first to consider whether the houses, habits and customs of the people cannot be so modified as to render the association between the rat and human population less close than it is at present. As things are, there is no limit to the amount of food and shelter that the average Indian house affords to the rat. Very little advantage is gained if the floors, walls and roof of buildings be so constructed as not to make it impossible for the rats to burrow therein, if such erections offer no lack of food and shelter to rats, and if ingress and egress through doors and other apertures be not prevented by some special device. In many parts of India one can see buildings that have been made "rat-proof," harbouring, all the same, a very large number of rats.

Even in *kutcha* buildings something can be done towards eliminating the rat. All measures that lessen the amount of food and shelter for rats automatically effect

a reduction in the number of rats. Protection of stores of food from the depredations of rats and efficient scavenging, are thus anti-plague measures of the first importance.

II. Protection of the Rats of a Community from Plague

Before embarking on a detailed description of active rat-destruction measures it will be well to consider how best to protect the rat population of any town from becoming infected with plague, or to make the ever present possibility of such an occurrance less likely. To this end it is important to bear in mind the methods by which plague infection is conveyed from place to place.

1. *Grain and plague.*—It is a common experience to find plague in towns and villages beginning in the close vicinity of markets and grain stores. The rat population of any given town or village is very much larger in the neighbourhood of market and grain stores than in other localities, with the result that when plague is present the rat epizootic is likely to be more widespread in such localities than elsewhere. It follows that grain exported from plague-infected towns to another goes from the part of the town of despatch where plague is most severe to part of the receiving town where the rat population is at a maximum. Further, grain and similar merchandise offer facilities for the transport of rats which baggage consisting of personal effects rarely affords. Plague-infected rats are likely to be much more harmful as plague-infecting agents than are fleas alone which, apart from their definitive hosts, are short-lived especially if infective.

It follows therefore that the methods of grain storage and grain transport are of paramount importance in plague-infected and plague-threatened India, where the grain trade is in a very special sense a "dangerous trade," and as such demands very close supervision. There is a large mass of epidemiological evidence to show that the rate of diffusion of plague-infection is very slow when it has to rely on the movements of human population *per se*, but the movements of grain afford facilities for

the dissemination of infection equalled by no other agency.

In discussing this matter it is important to bear in mind certain facts regarding the habits of rats cited above. They explain the logical basis of the following *desiderata* of grain stores :

(*a*) Wherever possible the wholesale storage of grain should be effected in buildings apart from those in which retail trade is carried on.

(*b*) Wholesale grain stores should not be situated in close proximity to densely-crowded areas of a city.

(*c*) Wholesale grain stores should never be utilised for purposes of human habitation.

(*d*) Bearing in mind that water is essential for the life of the rat, no water accessible to rats, or fresh vegetables should be allowed in wholesale grain stores.

(*e*) As rats are unable to circumvent a smooth horizontal projection of 9 inches, such a ledge surrounding a grain store on the top of a plinth 3 feet high, is effective in prohibiting the ingress of rats. On the sides of building, in which the doors are situated, this ledge can conveniently be enlarged into a platform 2 feet or 2 feet 6 inches in width. Reinforced concrete is a suitable material for such ledges and platforms.

(*f*) The roof of the godown should overhang this platform and ledge to prevent the accumulation of rain-water thereon.

(*g*) No steps or similar means of facilitating ingress should be allowed. For unloading sacks of grain designed for such a store the bullock cart can be pushed close to the platform, which is also at a convenient height to facilitate the deposit thereon of sacks.

(*h*) Rats will, from time to time, be introduced into such a store, but they will be compelled to leave in search of water and should find their return extremely difficult.

(*i*) In villages and places, where the cost of such *pucca* buildings is prohibitive, relatively rat-free stores can be made of almost any material, provided the roof is water-tight, by raising the floor on uprights surmounted by rat-guards similar in design to those commonly employed

on ships' cables. These uprights should be at least three feet high and would support the beams on which the floor rests. The floor might be made of wood. The space underneath the floor can be left open and kept free from weeds and rank growth with but little trouble.

2. *Other means of conveying plague-infection.*—Clothing and bedding from plague infected houses may contain infected rat-fleas : the chance, however, of such finding a susceptible rat as a host, without which they cannot give rise to an epidemic, is sufficiently remote to explain the fact that merchandise is a more potent source of plague-infection.

When articles from a plague-infected source are of such a nature as to render them likely to harbour fleas, they can be rendered innocuous by exposure to the direct rays of the sun. The ground used for the purpose should be so chosen that the sun is able to shine on it for the whole of each day. It should be flat, devoid of grass, stones, or anything which might afford shelter to fleas. Preferably it should be covered with a smooth layer of fine sand 3 inches deep. The surface temperature of the sand should be at least 120° F. to ensure the destruction of all fleas. One hour's exposure in such conditions is sufficient for the purposes of destruction. Thick coats and *rezais* should be turned once or twice during the process. No articles should be placed within 3 feet of the edge of the sand.

III. Rat Destruction

Careful attention to detail, and a knowledge of all that has been said above regarding the habits and customs of rats, are essential to success in any rat destruction campaign.

1. ***Rat** poisons.*—Poison, if intelligently used, can accomplish much : by means of a "poison campaign" a rapid reduction in the rat population can be effected. The selection of a suitable poison is the most important consideration. The most satisfactory of all poisons, and the cheapest, is *barium carbonate.* As a rat poison it is

certain in its action and safe to handle. When mixed with flour and water it in no way makes the mixture less palatable to rats who seem quite unable to detect its presence. Poison baits are best made as follows :—

One pound of powdered native barium carbonate is mixed thoroughly in an enamelled basin with three pounds of flour made from the grain which constituted the staple food of the locality in which operations are to be carried out. Sufficient water is added to make the whole into a fairly firm paste. The resulting mass is sufficient for some 2,400 baits, each containing three grains of poison, which are conveniently rolled into pill from. Clean hands and dishes are necessary to avoid imparting to the baits extraneous taste and odour which may diminish their attractiveness. Baits should be made fresh each day as a hard stale bait is rarely eaten by the rat.

Poison baits should be laid in the evening, and placed in situations readily accessible to rats. When baiting is being carried out special efforts should be made to keep all other available food for rats covered up, especially at night. In laying baits the presence of rat holes, or other indications of the presence of rats, will afford useful indications as to where baits can be laid with most chance of success.

If rat poisoning be carried out with careful attention to all these details, a very notable degree of success will be achieved, with very appreciable benefit when plague threatens.

2. *Trapping.*—To effect a considerable diminution in the rat population and to keep it at a low level by means of trapping is a relatively expensive measure and one that requires careful and intelligent supervision.

Many rat-traps on the market are defective in design and construction. Traps selected haphazard have very varying degrees of efficiency, and recent observations have shown that the size of the trap, the size of the inlet, the strength of the trap, the accuracy with which the flap fits the frame designed for its reception, are all important points in determining the efficiency of the trap. Other

things being equal, the larger the diameter of the inlet, the more satisfactory the trap.

Traps should be oiled only sufficiently often to ensure freedom from rust. Frequent washing of the traps is not recommended : rats are not attracted by cleanliness which appears to make them suspicious. During the war traps were found suitable for keeping the rat population reduced when once this had been effected by the use of the rat-poison. Traps operated by light counterpoised weight were more suitable than those worked by a spring.

The traps are best baited with a small quantity of the staple food-grain of the community or of flour made therefrom in the form of dough. In the hot months fresh green vegetables, notably cucumber, make an attractive bait.

All traps should be set overnight and collected early in the morning. All rats caught can be drowned or destroyed in some humane manner, their bodies being burnt. For systematic trapping a number of traps equal to 3 per cent. of the human population will be found sufficient. Frequent inspection of traps, with the rejection for repair of all found defective, is essential.*

C. *Anti-plague Inoculation* (*Haffkine*).—This consists of a cultivation of plague bacilli in bouillon, the bacilli having been killed and the solution sterilised by heat. The usual dose is 5 c.c. for an adult, and is injected into the outer part of the upper arm. The injection is followed by constitutional disturbance lasting for about twenty-four hours, and it makes the man unfit for work for two or three days. The immunity is established in about ten days after the inoculation and lasts for about six months, and often longer. Inoculate early during an epidemic. When once a bottle containing the vaccine is opened it should be used up ; if any is left it should be rejected, as after twenty-four hours it becomes unfit for use. The results of inoculation as attested by the Indian Plague Commission have been distinctly satisfactory, for although

* Summary of the preventive measures recommended by the Sanitary Commissioner with the Government of India.

absolute protection is not afforded, this method of treatment diminishes not only the total number of attacks amongst the inoculated but also the percentage of mortality amongst those attacked. The conclusions of the Commission are :—

(1) Inoculation is harmless. (2) When given in the incubative stage, *i.e.* before the signs of plague are apparent, it has in many cases the power of aborting the disease. (3) Inoculation affords to all those inoculated a strong protection against attack by plague. (4) In the few cases where inoculated people are attacked a very large proportion recover.

The following table * gives the number of attacks and deaths from plague :—

	Population.	Attacks.	Deaths.	Percentage of deaths to population.
Uninoculated	8001	487	350	4.3
Inoculated	1584	36	20	1.2

Disinfection.—To disinfect a plague-infected room the floor should be thoroughly swilled with kerosene oil or its emulsion, or pesterine. The fleas are to be found in the cracks and crevices in the floor. It is better to empty the room of all furniture ; and infected clothes, bedding, etc., should be either burnt or disinfected by steam. The wall up to 2 ft. or 3 ft. should also be treated with kerosene. About two pints of oil are required for every square yard, and a few ounces of the oil should be poured into each rat hole.

Solutions of perchloride of mercury or other chemicals are not of much value for disinfecting plague-infected rooms, where attention is chiefly directed against the destruction of rat fleas which harbour the bacilli.

Pneumonic plague is most infectious, as it spreads by inhalation. Attendants and nurses should always wear a mask when visiting patients. The best form of mask is a three-tailed gauze bandage with a pad of cotton-wool.

* Standage, *Transactions of the Bombay Medical Congress*, 1909.

This should always be destroyed after each exposure to infection.

Cholera

Cholera is an acute infectious epidemic disease characterised by profuse purging and vomiting of a colourless serous material, muscular cramps, suppression of urine, algidity, and collapse, the presence of a special bacterium in the intestines and intestinal discharges, and high mortality (Manson). It is endemic in certain river districts in India, *e.g.* Assam and the delta of the Ganges, and is principally a water-borne disease. It occurred in the form of minor epidemics in Europe during the Balkan War of 1913, and in the course of the last European War, especially in the Balkans and in Mesopotamia.

Ætiology.—The following are the conditions necessary for a widespread epidemic of cholera :—

1. The presence of the microbe.
2. A suitable medium and temperature for its growth outside the body.
3. Means of transport.
4. Susceptibility to the infection.

1. *The Virus.*—Koch in 1883 discovered in Egypt the comma bacillus supposed to be the cause of cholera. In 1881 he came to Calcutta and found the same bacillus in the stools of all the cholera patients then examined. It is a short, motile organism about half the length and twice the thickness of the tubercle bacillus. It is slightly curved like a comma. It grows in an alkaline medium at a temperature from 30° to 40° C. but does not thrive in an acid one. Its growth is arrested below 15° or above 42° C., and a temperature over 50° C. kills the bacillus. It is aerobic, but is nevertheless capable of growing to some extent in the absence of oxygen. The primary source of the virus outside the regions where cholera is endemic is the intestinal discharges of persons suffering from or who have recently suffered from the disease. It has been detected in the vomited matters, and its presence in the vomit is to be accounted for by the contents of the intestines finding their way into the stomach. The

comma bacillus has not been recovered from the blood during life, although Greig found it widely distributed in the different organs after death. He believes that the germ is distributed by the lymphatic system. It has been found in the gall bladder and in the stools of convalescents up to fifty days after recovery.

2. It is essential that the cholera vibrio must find some suitable medium outside the body for its growth. Such media are : (*a*) A soil polluted with organic matter, especially excreta ; (*b*) sewage polluted water ; (*c*) milk and other food. Greig has found that cholera germs are very non-resistant and die within about four days if kept in a dark room.

A suitable temperature is also necessary for its growth. Warmth and moisture are important predisposing factors ; on the other hand cold does not necessarily arrest an epidemic, as is evidenced by the various outbreaks in the Punjab where the temperature often comes down to zero. Epidemics generally occur in the late summer and autumn, and subside with the advent of winter to appear again in the next summer. The maximum periods of epidemic cholera incidence in Bengal are in April, May, and November, and in the Punjab at the height of the rains.

3. *Transport.*—Although atmospheric moisture is the carrier of the virus, it is not possible for the cholera germs to be transported to long distances by the *air.* The principal means by which the virus is carried about are :—

(*a*) *Human Intercourse.*—It is well-known that cholera is disseminated by human intercourse. This is proved by the fact that cholera often follows the lines of communication by river, road, rail, or ship. Kabul, for instance, has always received the infection from India and has been the centre from which it has advanced westwards. Although man is invariably responsible for introducing the disease to any place the spread of the disease depends entirely on the insanitary conditions, the primary cause being the liability of the drinking water to be polluted by the infected excreta. Although it travels along the trade route, it never advances far unless along its path there are places where the sanitary

conditions are such as will help the disease to take root and start upon its course afresh.

(*b*) ***Rivers.***—A polluted river may carry infection for very considerable distances to towns situated on its banks. The infection is usually carried up the big rivers by boatmen.

(*c*) *Carriers.*—Healthy contacts often harbour the cholera vibrios which they pass with their stools. It is possible that the cholera infected persons will carry with them the germs, deposit them in fresh places, infect water-supplies and set up epidemics without exhibiting any signs and symptoms of the disease themselves. This explains outbreaks in isolated places where the possibility of direct infection from an infected area is remote or cannot be traced.

(*d*) *Drinking Water.*—When the virus finds its way into the general water-supply of a locality the disease becomes widely diffused. This is very common in villages where there is no proper water-supply, and when the isolated tank or well becomes infected. Tanks are usually contaminated by washing soiled clothes and other infected articles in them. This is shown by the fact that the spread of cholera has decreased by the introduction of a pure water-supply. The average mortality of European troops at Fort William, Calcutta, was 20 per 1000 from 1826 to 1863. Since the introduction of filtered water up to the present time it has averaged 1 in 1000.

(*e*) *Milk, etc.*—Milk is not only a vehicle for diffusion but also a medium for growth. Many widespread epidemics may be traced to milk infection. *Insects* play an important part in the spread of the disease mechanically, by settling on articles of food after having been in contact with infected materials. The common house fly acts as an active agent, and it has been shown that the germs are capable of living for at least fourteen days in the fly.

4. Individual susceptibility counts for much in the matter of infection. Chronic alcoholism by causing gastro-intestinal catarrh predisposes to cholera.

Prevention.—The prophylactic measures may be considered under the following heads :—

I. Personal Prophylaxis :

1. Correct any tendency to dyspepsia and derangement of the stomach. In man digestive disturbances are often an important predisposing cause of an attack.

2. Promote the secretion of the gastric juice by keeping the stomach always full, an acid medium being hostile to the life and growth of the cholera germs.

3. Avoid foods that may cause indigestion. Unripe or over-ripe fruits, shelfish, or foods in a state of decomposition should be avoided.

4. Avoid any food or drink while travelling by railway. Cold dishes, ice puddings, ice creams, etc., should be rejected and everything taken hot.

5. Avoid bazaar-made aerated waters. Freshly manufactured soda water should not be taken, and three or four days must be allowed for the carbonic acid to exert its destroying action on the comma bacillus.

6. Purgatives, particularly salines, should be avoided.

7. Water for drinking purposes and for washing dishes, etc., should as a rule be boiled. Filters are not to be relied on. Weak tea, lemon juice, *dahi* or butter-milk, cocoanut water, can be used with impunity.

8. Diarrhœa during an epidemic should be promptly stopped.

Anti-cholera Inoculation (Haffkine).—Haffkine prepares two vaccines of different strengths : (*a*) An *attenuated* virus in which the virulence of the organisms is diminished by passing a current of sterile air over the cultures ; (*b*) an *exalted* virus in which the virulence has been increased by growth in the peritoneal cavity of a series of guinea-pigs. The dose of each is 1 c.c. The patient is first injected with the attenuated virus then after a lapse of three to five days with the exalted one. This method has been given up by Haffkine who has since recommended immediate inoculation with virulent, recently isolated vibrios, without further preparation. In 1912, 8,000 Europeans were inoculated in Batavia and there was only one death as against 15 deaths amongst

2700 uninoculated. Subsequent experience obtained during the last Balkan and the European Wars placed Haffkine's vaccine on a firmer basis. Recently Castellani has advocated, and used with promising results, a mixed vaccine of B. typhosus, B. paratyphosus A and B plus vibrio cholera killed by 0.5 carbolic acid. The number of organisms per c.c. is as follows :

Typhoid	500,000
Paratyphoid A	250,000
Paratyphoid B	250,000
Cholera	1000,000

about 10 ms. or 0.6 c.c. is given at the first injection and double the dose at the second a week later. The reaction is not very severe and the inoculated person is fit for work 24 to 36 hours after injection.

II. General Propylaxis.—This may be discussed under the following heads :—

1. *Notification.*—Early notification is of utmost importance. In Calcutta this is obligatory by law. In villages, the village Chaukidars are ordered to report cases of cholera to the local police who has to report daily the Civil Surgeon, during an epidemic. Early notification helps the adoption of immediate steps against the disease before it has time to spread. But to be successful every step should be taken as early as possible. For this purpose, quicklime, posters, etc., should be kept in each Union Board, and the Chaukidars and the Duffadars drilled in their use. Cholera prevention centres should be established at convenient places where supplies of other chemicals required for sterilising water and disinfecting clothes, excreta, etc., shall be kept.

2. *Isolation of Cholera Cases.*—The isolation of the sick and segregation of the contacts are possible only in towns. But in villages all that can be done is to instruct the inmates of the infected house not to mix with other villagers and at the same time to warn the villagers not to visit the infected houses, or to take water from the same source.

3. *Sterilising Water.*—Although recent investigations have shown that not infrequently cholera germs are

carried by means of flies from infected excreta to food, or more directly by the handling of food by human carriers, thus giving rise to sporadic cases of the disease, the fact still remains that in the vast majority of instances explosive outbreaks of cholera are almost always due to the use of infected water ; and this view has been proved to hold good especially in those cases where a considerable number of persons are simultaneously attacked with the disease. It is safe to assume, therefore, that water, polluted by the excreta of cholera patients or carriers, is the chief factor in the spread of epidemic cholera, and that when the necessity arises for preventing or controlling the spread of such epidemics, the measures called for are primarily those aimed at the protection of all water-supplies from contamination, and the immediate disinfection of those supplies which are believed to have been exposed to risk or pollution.

The following different methods may be adopted for purifying drinking water for the prevention of cholera, viz. :—

(*a*) Boiling.
(*b*) Chlorination.
(*c*) Permanganate of Potash.
(*d*) Reservation of Tanks.

(*a*) *Boiling.*—By this simple method the infected water may be purified most easily and efficiently. Since it is not possible to boil water for the whole community, the individual householders will remove the chief source of danger of cholera infection by this simple procedure.

(*b*) *Chlorination.*—In *bleaching powder* or *chlorinated lime* and solutions of the hypochlorites, we possess agents of extraordinary efficacy in the disinfection of water. Experience in the recent war has conclusively proved the special value of systematic chlorination of water-supplies as a practical measure of prevention against cholera and other water-borne diseases.

The bactericidal action of bleaching powder and solutions of the hypochlorites depends upon their power of setting free nascent oxygen, which has special affinity for organic matter generally and bacteria in particular.

The disinfectant, proportionate to the size of the tank to be treated. is first placed in a bag, which is then attached to ropes and by this means pulled backwards and forwards through the water, particular attention being paid to the portion near the edges, which is most likely to harbour infection. For a tank five feet deep and one acre in extent 15 lbs. of active bleaching powder will suffice. So active is the sterilising agent that usually within 15 minutes the vast majority of the germs that may be present are destroyed, and it is probable that in most cases an infected tank may, by this means, be rendered harmless within an hour. For use in wells and cisterns, and in the case of piped water-supplies which may be suspected of contamination, solutions of the hypochlorites are more convenient than chloride of lime.

(*c*) *Permanganate of Potash.*- This has already been discussed on page 27.

(*d*) *Reservation of Tanks.*—Even in the absence of any disinfecting agents we are not entirely powerless against cholera. The cholera organism is very easily destroyed. Thus the water of an infected tank will purify itself and become safe for use if it is exposed to air and sunlight for a few days. The use of a tank, suspected of being infected with cholera, should be rigidly forbidden for a definite period. In dry weather three to four days are enough, while in wet or cloudy days seven to eight days are necessary. Tanks that are not overshadowed with trees and vegetation will purify themselves most rapidly. Natural purification is very slow in wells and should not be relied upon.

The following additional precautionary measures should be adopted for the safety of the community at large :—

1. All sources of water supply should be protected and all infected tanks and wells should be placed under guards for at least a week and no one allowed to use their water under any circumstances.

2. Persons from infected areas or houses should not be allowed to dip their buckets into an uninfected well or tank, and should not be allowed even in their vicinity.

5. While arranging to secure efficient treatment for actual cases, the greatest emphasis should be laid on preventing the spread of infection.

6. Arrangements for drawing water should be made through a man especially appointed for this purpose.

7. Particular attention should be paid to the cleanliness of the cook and of the cook-house.

8. All privies and drains should be daily disinfected.

Disinfection.—Cholera is contracted through the mouth by taking water or food infected with the discharges of the cholera patients, or by the accidental soiling of hands through touching cholera patients or infected clothing, etc., soiled with their discharges. Since the discharges of the cholera patients are the actual source of infection, special care should be taken to disinfect the stools, urine and the vomit.

Infected discharges, excreta, etc., should be burnt as soon as possible. The metal vessels should also be placed on the fire and disinfected. Quicklime may be used for the excreta and vomit. A handful is placed in the vessel containing the stool, then enough hot-water is poured on to it and the whole mixed up with a stick. This will disinfect the stool within 2 hours. Milk of lime may be used for disinfecting stools, spoiled floors, clothes and utensils. It should be used in excess, and atleast a two hour's exposure should be given. Bleaching powder may be used to disinfect the discharges.

Floors should be disinfected by thoroughly flaming them with a painter's blow-lamp or by using freshly slaked powdered lime or bleaching powder, or by milk of lime.

Soiled clothes are best disinfected by boiling for 15 minutes, or may be soaked in milk of lime for an hour, rinsed in boiling water and finally dried in the sun. Solution of bleaching powder (3 oz. to a gallon) may be used for clothing, but it injures the fabrics and the article must be washed in hot water. Perchloride of mercury lotion (1 in 500), carbolic acid (1 in 20), formalin (1 in 10), cyllin (1 in 100) may be used.

Utensils, cups, plates, etc., are best treated by immersing them in boiling water for fifteen minutes. They may also be disinfected by placing for an hour in milk of lime and then washing with hot water.

Hands are best disinfected with the thorough use of soap and hot water, after this they may be immersed for a short time in solution of lysol, cyllin, or perchloride of mercury (1 in 500).

Anti-Cholera Propaganda.—This is likely to be very effective during an epidemic. The people should be taught the principles of cholera infection, how the disease spreads and how it can be avoided. They should be impressed on the importance of protecting the water supplies from pollution by human excreta, explained how to purify the water, and still more how boiling the water will help protection. The importance of disinfecting the floors, clothing, utensils, and the use of soap and water for cleaning the hands must be insisted upon. In this educational work the use of posters and leaflets are of great advantage. Under certain conditions popular lectures, illustrated by magic lantern slides, are likely to be helpful and full use should be made of any opportunity to employ them.

DIPHTHERIA

Diphtheria is an infectious disease usually of the mucous membranes transmissible from the sick to the healthy—the cause being a micro-organism (Klebs-Loeffler bacillus).

Ætiology.—Diphtheria is a widely spread affection and like most infectious diseases is prevalent only in certain seasons. The influence of soil and rainfall upon the prevalence of this disease has led to much discussion and debate. Newsholme holds that epidemics are very common in dry years when the total annual rainfall is materially below average, which implies very low ground water. He holds that the micro-organism of diphtheria passes a saprophytic existence in the soil, and that its growth is favoured by a low level of the ground water.

Epidemics of diphtheria usually commence with the advent of the cold weather, and the maximum death-rate is reached in November and December.

It is believed that sore-throat or some damage to the mucous membrane of the throat like catarrh, measles, scarlet fever, etc., predisposes to attacks of diphtheria, but some are peculiarly susceptible to it. The incidence of this disease is mostly limited between the ages of two and twelve years. Age has also a marked influence on the case-mortality. It is most fatal to infants under one year ; the mortality then gradually falls up to the fifth year, and after that more rapidly, but rises again after forty.

Schick has shown that the presence or absence of immunity against diphtheria can be ascertained by a special test known as "Schick Reaction". This is done by injecting $\frac{1}{50}$th of a minimum lethal dose of diphtheria toxin for a guinea pig weighing 250 grms. A reddened area with a white centre at the site of the injection denotes positive reaction. Those giving positive reaction indicate absence of antitoxin in the blood, and the particular individuals are susceptible to diphtheria. This test is of great practical value as it enables one to determine the presence or absence of immunity of a person during an epidemic. Those giving a negative test do not require prophylactic injection of antidiphtheritic serum.

Mode of Spread.—The most common mode of spread is by personal communication, and outbreaks generally occur in crowded localities, and may be caused either directly or indirectly. Directly, the virus may be transmitted by kissing, coughing, by droplet infection, sneezing, etc., and indirectly by means of handkerchiefs, toys, through slate pencils, etc. The bacillus grows well in milk which may be a medium of infection. The so-called diphtheritic affections of pigeons, poultry, and calves are as a rule diseases quite distinct from human diphtheria, and are not communicable to man (Hewlett).

The bacillus is very sensitive and dies soon under the influence of light, heat and disinfectants. Therefore

infection through the medium of air is only possible within a few feet of the infected person.

The *incubation period* is short and varies from a few hours to five days. It has been traced to carriers, in whom it is the cause of persistent suppuration of the ear or nasal sinuses, or tonsillitis, or may cause no discoverable symptoms. These carriers may or may not have had a previous attack of the disease. Patients and nurses may harbour the germs for a long time without showing any outward signs of the disease. These carriers are the sources of infection to others. It is necessary, therefore, that the mouth and throat of such persons should be washed with some antiseptic lotion and the throat sprayed with chlorine water. The mucus from the throat and posterior nares should be examined bacteriologically for the presence or absence of the bacillus, either in smears or in cultivations, made from the membrane or secretions. The mild cases are those which it is of the greatest importance to identify, especially in schools, for if not recognised the patients may go about and prove a source of infection.

One attack gives no protection against a second one. The period of infectiveness has been variously estimated ; so long as the bacilli are present in the throat infection must be possible, and the length of time for which they may occasionally persist is remarkable. They may disappear within three days of the disappearance of the membrane, or may last for as long as three weeks. Hewlett mentions a case where it persisted for no less than fifteen months after the attack. It is not safe to allow convalescents to mix with healthy children until after the disappearance of the bacilli from the throat, and this point can only be definitely ascertained by bacteriological examinations of smears from the throat.

Prevention.—The disease sometimes occurs in an epidemic form in schools, hospitals, and similar places. The most important measure of its suppression is isolation not only of all such cases but also the possible carriers. But this is only possible in institutions where there is some sanitary control. All persons

in the particular house should be tested for Schick reaction, and those giving positive reaction should receive prophylactic injection of anti-diphtheritic serum. The usual dose is 1000 units, but Schick recommends 50 units per kilo of body weight. This dose requires to be repeated every ten or fifteen days, as long as the chances of fresh infection exists. The details of other preventive measures to be observed are practically the same as described under small-pox. Particular attention should be paid to the discharges from the nose and throat. These as also the clothing and bedding should be thoroughly disinfected.

The individual is protected not only by the use of prophylactic serum but also by using separate glass, cup, spoon, towel, etc. Rigid cleanliness of the hands, mouth and throat should be observed. Use of some disinfectants for washing the mouth and throat is useful.

Small-pox

Small-pox or variola is a contagious specific fever, attended on the third day of illness by a characteristic eruption of the skin, papular and ultimately pustular.

Small-pox is known to have been indigenous in Eastern countries and its earliest records are from India and China. Its distribution is world-wide and it is essentially an epidemic disease, although it must be regarded as endemic nearly everywhere in India. According to Holwell small-pox rages epidemically in Bengal every seventh year during the month of March and the two months following it, and sometimes until the rains. In India the maximum prevalence of the disease is during the hot weather; while in cold countries it is most prevalent during the late winter and early spring. The prevalence and mortality of small-pox are much influenced by vaccination.

This is one of the most virulent and infectious of transmissible diseases, and persons unprotected by vaccination are almost universally attacked on exposure.

The mortality appears to be higher among males than among females, and the disease is most fatal in children between the ages of two and four. The death-rate from small-pox in India varies from 0.3 to 2.0 per 1000 per annum, and about 20 per cent. of the persons attacked die. In 1909 there were 3784 deaths from small-pox recorded in Calcutta and after that the city was practically immune. In the years 1910, 1911, and 1912 the total number of deaths were 48, 41, and 77 respectively. In **1920** there were **3,000** deaths in Calcutta.

Infectivity.—The *incubation period* of the disease is usually twelve days, but it may be as short as five days, or as long as three weeks. The disease is infectious from the earliest period of its manifestation, probably by the breath, and the danger continues during the whole course of its progress, but particularly after the pustular stage, when the scales begin to separate. Therefore the patient should be isolated until the last scab has fallen off. The ratio of persons who are entirely insusceptible to small-pox is, according to Notter and Firth, 1 in 20 for adults and 1 in 60 for children. The contagion is very persistent and it may act through a considerable distance. It is exhaled from the skin and lungs of the patient, is probably contained in the secretions and excretions, and adheres to clothing, articles and places with which the patient may have come in contact.

Air is the medium through which the contagion is chiefly transmitted. Houses within a radius of half a mile of a small-pox hospital have been attacked at three times the rate of those between half a mile and a mile, and at four times the rate of those beyond a mile. Flies and possibly mosquitoes may have some share as carriers. The commonest cause is perhaps direct contact or proximity to a case—a proximity close enough to allow the throat or nasal secretions or skin debris to be inhaled by the person infected. Whether the disease is spread through the air or through the carelessness of persons connected with the hospital is still disputed, and in the absence of any exact knowledge it is better to locate small-pox hospitals as far from inhabited areas as possible.

One attack generally confers immunity for the rest of the life. A second attack, however, is not uncommon and may occur even after an interval of one year ; a third attack is not unknown. The protection, however, tends to wear off in course of time. It should also be borne in mind that complete natural immunity even after repeated exposure is occasionally seen.

The cause is not known, although various organisms among others two or three protozoon-like bodies have been described. But these have not received general acceptance.

Prevention.—The following measures should be adopted during an outbreak of small-pox :—

1. Vaccination

By *vaccination* is meant the introduction into the human system of *vaccinia*, which is small-pox attenuated or weakened by its passage through cows, and is not a spontaneous disease of the cows. Instead of a general eruption all over the body vesicles appear only at the points of inoculation, with the result that the small-pox loses its power to spread in a well-vaccinated country, except in rare cases by aerial convection.

Jenner in 1798 first pointed out that the inoculation of man with cow-pox (*vaccinia*) confers immunity to subsequent attacks of small-pox in the same way that an attack of small-pox does to a patient. Many experiments were made to confirm these results, and the practice of vaccination became more general.

Duration of Protection.—The protection afforded by vaccination is less perfect and less permanent than an attack of small-pox. The susceptibility to small-pox after a primary vaccination returns slowly, and the duration of protection afforded by vaccination depends upon (*a*) the quality of vaccination, *i.e.* the number, area, and the character of scars ; (*b*) the time which has elapsed since its performance ; (*c*) the mode of its performance—vaccination in three or four places gives better protection than that conferred by vaccination in only one spot.

Whenever possible primary operations should be performed at six points.

Vaccination was made compulsory in Calcutta in 1880. The mean ratio of deaths per 100,000 of the population per annum for nineteen years previous to this was 116.8, and for nineteen years subsequent 44.5.

Small-pox can be almost entirely prevented by vaccination. Formerly the disease was so prevalent that almost everyone suffered from it. As a result of the extensive use of the vaccination the disease has almost been exterminated from many countries. Thus there were only 8 deaths in the year 1897 in the entire German Empire with a population of 54,000,000.

A widespread epidemic of small-pox can only be attributed to ignorance concerning the prevention of the disease by vaccination and re-vaccination. By immediate vaccination, all persons brought directly or indirectly in contact with the case, the progress of the disease can almost atonce be checked. It is therefore necessary that the physician, attendants, the relatives of the patient, and in fact all the inmates of the house should be vaccinated. If possible the residents of the adjacent houses should also be vaccinated. If vaccinated within a day or two after exposure to small-pox the person often escapes the disease. If however he does contract the disease it generally appears in a much milder from. If persons exposed to small-pox are not vaccinated they should be placed under the quarantine for sixteen days from the date of last exposure. No person who has not been vaccinated within five to seven years, and no person who has had small-pox for seven to ten years previously should rely upon the supposed immunity.

When visiting a small-pox patient the physician should wear a long over-all fitting close about the wrist and neck. Failing this he should have a change of clothing. These garments should be removed immediately and placed in an airtight receptacle and should be disinfected with formalin vapour. The hand should be thoroughly washed with soap and water and then washed in some strong aniseptic solution.

The Operation of Vaccination.—This is usually performed on the outer side of the arm near the insertion of the deltoid muscle. The anterior surface of the forearm 2 in. below the bend of the elbow or the calves of the legs are also selected as sites for vaccination. The leg is the preferable site rather than the arm since the abundant lymphatics of the groin control better the inflammatory reaction than do the less developed ones of the axillary region. The part should be thoroughly washed and cleansed with soap and water, and then with some antiseptic lotion, and finally flushed with clean water to remove all traces of the antiseptic, and then the lymph taken on the point of a sterile lancet is inserted by punctures or scratches. It must be remembered that any strong antiseptic will counteract the object of vaccination. Absolute alcohol is therefore better and should be allowed to evaporate after having done its work. The vaccinating lancet can also be sterilised by wiping with absolute alcohol or rectified spirit. The part should be stretched and the lancet should be held at an angle so as to make valvular incisions which should enter but not penetrate the true skin. It should be sufficient to cause a little blood-stained lymph to exude.

Instruction to Vaccinators.—1. Vaccinate only healthy subjects. Infants suffering from fever, irritation of the bowels, skin eruptions, or chafing or eczema should not be vaccinated.

2. Do not vaccinate in a house where there is a case of erysipelas.

3. Never make less than two insertions—four is better—and care should be taken to make the insertions so far apart that they do not run together and form one large sore. The area should be covered with a clean cloth after allowing some time to dry. According to Schomberg, painting the points of inoculation after forty-eight hours with a 4 per cent. solution of picric acid in alcohol, markedly lessens local reaction and danger of secondary infection without interfering with the success of vaccination.

4. Particular care should be taken to protect the vesicles ; the crusts should be left until they drop off. Ordinarily no dressing is required.

5. In primary vaccination only enter as "successful" those cases in which the typical vaccine vesicles have been produced ; in re-vaccination only those in which either vesicles, either normal or modified, or papules surrounded by areolæ, have been produced.

6. Whenever practicable vaccination should be done with preserved calf vaccine. In arm to arm vaccination ascertain that the children you take the lymph from are of healthy parentage, and have no signs of any hereditary disease, especially syphilis. Lymph should be taken from typical vesicles around which there is no conspicuous commencement of areola. The practice of vaccinating direct from the calf or from arm to arm is to be discouraged.

7. When performing a number of operations use two lancets, put the used one in boiling water for sterilisation.

A vaccinator should vaccinate at once all the members of a household or contacts in case of an outbreak of small-pox in the house, and also re-vaccinate people during epidemics irrespective of the length of time that has elapsed since the last vaccination.

There can be no danger from vaccination except what is common to all wounds, which is avoided by proper attention to cleanliness.

Age of Vaccination.—In Bengal the Vaccination Act enjoins that a child should be vaccinated within six months of its birth, but the best age appears to be four months, that is before the child can turn over. A properly performed vaccination, even to a new-born babe, is practically without any danger. Children are very highly susceptible to small-pox, and the younger the child the less is the resisting power. If there be any reason to suspect that the child may develop small-pox, vaccination should at once be performed.

Re-vaccination is also necessary, as the protection afforded by primary vaccination gradually wears off.

Young people had better be re-vaccinated before attaining puberty and during an epidemic. The protection afforded by vaccination lasts for about seven years. But different persons acquire immunity with varying rapidity and likewise retain it for varying periods. Vaccination performed soon after the exposure to the infection can partially or completely protect the patient from the disease or favourably modify its course. In fact, small-pox is entirely prevented if persons are vaccinated within two days after exposure, and if vaccinated on the third day it is " modified " and rendered less severe. Natural insusceptibility to vaccination is sometimes observed, when even fresh virus carefully applied repeatedly fails. These cases are probably also immune to small-pox, but these persons should be vaccinated during epidemics since we have no means of ascertaining when this natural immunity may lapse. A person can only be declared insusceptible to vaccination if he is thrice unsuccessfully vaccinated in succession.

Phenomena of Primary Vaccination.—At the end of the second or third day after vaccination a slight elevation can be felt, and on closer examination about half a dozen small vesicles may be observed which gradually run together and form one large vesicle with a depression in the centre on the fifth or sixth day. The vesicle matures on the eighth day, becomes greyish, tense, and loculated, and contains a clear viscid lymph which exudes when the vesicle is pricked. The vesicle begins to be pustular and becomes surrounded by a red ring, the " areola," on the ninth day. During the development of the pock slight constitutional symptoms such as fever, restlessness, and itching are observed. About the tenth day it begins to dry up and there remains a dry brown scab about the 14th day, and the scab falls off about the 21st day. The scar or cicatrix is depressed and marked with little pits (foveated).

Vaccination is not successful unless the areola or red zone around the vesicles is formed. When lanolinated lymph is used the areola commences to form on the 5th day, but with glycerinated lymph it takes about two more

days for its development. The vesicles have a doughy feel and do not fluctuate as in the case when pus is formed. Opinions are at variance as to whether vaccination, performed at any time during the period of incubation, confers complete or partial immunity or only favourably modifies the course of the disease. For complete protection, vaccination should be performed immediately after the reception of the contagium. Vaccinia only begins to exert prophylactic power when the areola commences to form round the vesicle.

2. *Isolation* :—The patient and the suspect should be separated. All comunications between the sick and infected and the healthy (other than the attendants), and the movement of any article from the infected room or house should be rigidly forbidden.

3. *The Sick-Room.*—The contagion of small-pox harbours in carpet, beddings, clothing, etc., and therefore carpets, pictures and all unnecessary furniture, clothing and bedding, and any other articles capable of harbouring infection, and which would be difficult to disinfect or not desirable to burn, should be taken out of the sick-room. Articles or furniture that have already been exposed to infection should not be removed unless those have been disinfected. The room should be fully ventilated. Ten per cent. solution of formalin may with advantage be kept in the room in a vessel.

4. *Care of Convalescents.*—No person recovering from small-pox should be allowed to go out and receive visitors until every scab, crust and scale has disappeared, and there is no sore in the body. The hair should be carefully brushed to remove all particles adhering to the scalp and the whole body should then be thoroughly washed with soap and water. He may have a bath with some antiseptic lotion, and clothing previously worn should be thoroughly disinfected under the direction of a responsible officer.

5. *Care of Corpses.*—All persons dead of small-pox should be wrapped in sheets with a 40 p.c. solution of formalin and should be cremated or burnt with as little

delay as possible. When coffins are used they should be air tight.

6. *Disinfection.*—The infected house and its contents should undergo a most thorough disinfection. It is essential that this work should be carried out properly. All openings into the room should be closed, excepting the door. Any cracks or open spaces, key-hole, etc., should be pasted over with slips of paper. Clothing, bed cover, etc., should be removed and hung or stretched across the room; matresses and pillows should be opened up and the contents exposed. Drawers, trunks, cupboards, almirahs, etc., should be opened and the contents removed and spread out on the floor. As soon as the disinfectant is placed the doors should be closed and the room kept closed for from 4 to 6 hours. After this the doors and windows should be thrown open and a full circulation of air allowed. Finally all articles of clothing, beddings, etc., may be kept exposed to the sunlight. Rooms, offices, boats, vehicles, etc., which may have incidentally been exposed to infection may be washed with soap and hot-water, and then disinfected with 10 p.c. solution of formalin, or fumigated with formalin or sulphur vapour. Leather goods, fur, books, etc., which may be damaged by other methods of disinfection should be disinfected by dry heat.

As the nose and throat are liable to harbour the specific cause of small-pox they should as far as possible be cleansed, and gargled with some disinfectant.

Preparation of Calf Vaccine Lymph

Preparation of Calf.— The calf is kept in quarantine for a week to see that it is healthy. If so, it is strapped on a table and the lower part of the abdomen is carefully shaved. The shaved area is first washed with a 5 per cent. solution of carbolic acid and then well syringed with clean filtered water and finally cleansed with sterilised water. The wetted area is dried by means of sterilised gauze sponges.

Vaccination of Calf.— The calf is then vaccinated with glycerinated calf lymph introduced into the skin through

numerous parallel linear incisions made by a sterilised scalpel. The scalpel must be frequently dipped in the vaccinating fluid. As these incisions are made, additional lymph is run in along the cut by the aid of a sterilised blunt instrument such as an ivory spatula. It is necessary to inoculate the incisions immediately they are made, otherwise the lips of the wound are apt to swell and close the opening. After the vaccination, the shaved surface should be covered with a sterilised apron and the calf can then be removed to the stable.

Collection of Vaccine Material.—After 120 hours (five days) the calf is placed on the table and the vaccinated surface is carefully but thoroughly washed with soap and warm water. This may be done either by the clean hands of the operator or with absorbent cotton-wool. It is next washed with filtered water and finally with sterilised water. Next any crusts which may have formed should be removed by a sterilised rubber pad. Excess of moisture on the surface may be absorbed by means of sterilised gauze sponges. The skin is then put on the stretch and the contents of the vesicles are collected with a sterilised Volkmann's spoon. Each line must be taken in turn and must only be scraped once. In this way the vesicular pulp is obtained without admixture of blood. The pulp obtained is placed in a sterilised stoppered bottle of known weight. It is then carefully weighed. The abraded surface of the calf is then dusted over with starch and boracic acid powder.

Glycerination of the Vaccine Material.—The lymph pulp is next transferred to a triturating machine—all parts of which should have been previously sterilised by prolonged steaming. The pulp is passed through the machine and thoroughly triturated. To test its complete trituration a loopful of the ground-up material is suspended in a watch-glass of distilled water. If the trituration is complete no particles will be visible and the water will be made merely cloudy.

The pulp is now passed through the machine a second time together with six times its weight of sterilised mixture of 50 per cent. glycerine in distilled water. This mix-

ture of pulp and glycerine water is then once more passed through the machine, thus producing a fine and intimate emulsion. Before preparing to store the emulsion, a loopful of it should be taken with a sterilised platinum needle and agar-plates inoculated with it.

Storage of Emulsion.—The emulsion in the machine is received into sterilised glass test-tubes of a size that can be filled as completely as possible, so that very little air remains in contact with the emulsion. Each tube is plugged with a sterilised cork, is sealed with melted paraffin wax, and is then placed in a dark cool cupboard or ice chest. Each tube should be marked with the number of the calf and the date of the preparation.

The Issue of Lymph in Capillary Tubes.—The emulsion may be tested on agar-plates after a month, and if no growth is shown the lymph may be drawn into sterilised capillary tubes and used for vaccination purposes. If growth takes place the lymph must be kept for a longer period until it ceases to cause growths. The capillary tubes should be sealed in a flame immediately after they are filled. If the special bottle for filling by means of compressed air be used it must be sterilised beforehand. Metallic collapsible tubes having a capacity to hold 25 to 50 grains are also used for issuing lymph, but these should first be properly cleaned and sterilised, and after filling corked and capped properly to prevent leakage.

General Instructions.—The use of unripe lymph, that is lymph containing contaminating microbes, is followed by fever, inflammation, and perhaps pus production. The use of stale lymph, generally so after eight months, on the other hand, simply results in more or less failure.

If stored in the cold, the lymph retains its activity for a much longer period. During the cold weather in Bengal the lymph when taken out of the ice chamber usually keeps well for about 10 to 14 days, but in summer it deteriorates in 4 or 5 days.

For every operation the vaccinator must thoroughly cleanse his hands, first with strong soap and warm water, then with a 5 per cent. solution of carbolic acid, and finally with sterilised plain water; and no assistant must be

allowed to touch the vaccinated surface of the calf's stomach before the lymph is taken nor any of the instruments, tubes, sponges, etc., unless with the same precautions.

All glasses, tubes, instruments, gauze, sponges, etc., must be completely sterilised before use, and the operator must himself see that the articles to be used are thoroughly sterilised.

Instead of glycerine the pulp may also be mixed with dehydrated and neutral lanoline in the proportion of one part of the pulp to two of lanoline (by weight), and then stored in sterilised tubes. One grain of this vaccine lymph is necessary for vaccinating three persons. The glycerinated lymph is to be preferred to the lanolinated variety.

The lymph of either variety, however, deteriorates on coming in contact with heat or even a weak antiseptic. The lancet, therefore, if sterilised by passing through a flame, should be allowed to cool down, and the area thoroughly flushed with clean sterile water and then carefully wiped dry before performing the operation.

Summary of measures for dealing with outbreaks of small-pox

(1) Every effort should be made to find the source of infection and to prevent the spread of the disease.

(2) As soon as a case of small-pox has been reported, the movements of the patient during the preceding two weeks should be ascertained, and all persons who have been in contact with him since the illness must be vaccinated or re-vaccinated.

(3) The most difficult persons to deal with are the ignorant labourers, who disperse in all directions, and in this way carry the infection to other centres.

(4) Where special hospitals exist every endeavour should be made to induce such cases to go into hospital. If they cannot be segregated in this way, they should, as far as possible, be isolated in their own dwellings.

(5) Contacts should be kept under observation for at least two weeks.

(6) Other steps include free vaccination throughout the locality. This may be done by empowering every medical practitioner to vaccinate all persons who apply to him. The local authority may supply lymph to the practitioners free of charge.

(7) In extreme cases, employ an army of assistants to go from door to door for the purpose of persuading people to be vaccinated. Female vaccinators will often be found to be of service for vaccinating women and young children.

CHICKEN-POX OR VARICELLA

Chicken-pox is a contagious disease occurring in children mostly in an epidemic form. It very often coincides with epidemics of small-pox, but the mortality is practically nil.

Ætiology.—There is no doubt that it spreads by a contagium from a previous case of the disease. Personal contact or fomites very often convey the contagium but no specific organism has been isolated. The *incubation period* is about fourteen days and the patient should be isolated until the last scab has fallen off.

Chicken-pox and small-pox are separate and distinct diseases and an attack of one does not give protection against an attack of the other. Vaccination gives no protection against chicken-pox. The following scheme on page 482 presents in contrast the salient features of variola versus varicella.*

Prevention.—All cases should be reported to the Health Officer, as very often a mild case of small-pox may be mistaken for chicken-pox and thus escape control. It may prevail in an epidemic form, and although not as a rule fatal may give rise to much trouble, especially in schools, boarding-houses, jails, hospitals, etc. The patient should always be isolated with a special nurse. The measures taken to prevent the spread of small-pox are

* Green's *Encyclopædia of Medicine.*

also applicable to chicken-pox. After separation of all the crusts the patient should have a warm bath and complete change of clothes before regaining perfect freedom. The room should be thoroughly washed and cleaned, and all clothes, bedding, etc., used by the patient subjected to a thorough disinfection either by steam or boiling.

SMALL-POX	CHICKEN-POX
Prodromata severe	*Prodromata slight or absent.*
Heavy sickness, severe pain in back, vomiting.	*Perhaps* slight headache, pain in back, shivering.
Spots come out on third day. Spots come out in progressive order from above downwards—face, hands, and arms, trunk, legs, feet.	Spots come out on first day. Spots come out in successive crops, the new spots being widely distributed.
Temperature: three days' pyrexia at onset, and pyrexia again when suppuration occurs, about the ninth day (called the secondary or suppurative fever)	Temperature not high as a rule. But pyrexia accompanies each fresh crop of spots if the eruption is profuse.
Liable to have very severe complications and sequelæ.	Neither complications nor sequelæ to be reckoned with, as a rule.
The centre of the vesicle is depressed.	The centre of the vesicle is the highest point.
Eruption apt to leave pits, often deep and permanent.	Pitting occasional, and slight as a rule.

MEASLES

Measles is a specific infectious fever characterised by macular eruptions and widespread catarrh affecting chiefly the respiratory, nasal, and ocular mucous membranes. It occurs generally in an epidemic form and is infective from its very beginning. Its distribution is universal, and the disease is independent of climatic influences. Children under the age of five are mostly affected, and the mortality is greater among males than females, especially among children under two years of age. The death-rate is higher among the poor and in overcrowded localities.

The *incubation period* is fairly constant and is ten to eleven days in most cases, although it may be as short

as six and as long as fifteen days. A true relapse is rare, although second attacks are not very uncommon.

Ætiology.—The specific cause is unknown, although experiments on monkeys have demonstrated that the virus is filtrable through porcelain bougies capable of holding back all known bacteria. The infectivity is probably lost by the time convalescence is reached. The nasal and bronchial secretions seem to carry the virus, the scales having been found non-pathogenic for monkeys even at the height of the disease. Direct contact with a previous case of measles is the most important factor in the spread of the disease. Its propagation may be effected indirectly through the agency of infected articles. The infection may be given off by the breath and mucus. The poison is also diffused through the medium of air and infection probably occurs by inhalation. Hektoen experimenting on human beings has shown that the cause of measles is present in the nasal secretions, scrapings of the skin, and the blood of patients during the earlier part of the eruptive stage. He further states that the chief bacteria in measles are—(1) The diplococcus of Tunnicliff in the mouth and throat; (2) Influenza bacilli; (3) Hæmolytic streptococci.

It is highly contagious in the pre-eruptive stage, and since the nature of the disease is not recognized at this period most damage is done.

Quarantine.—For contacts, eighteen days, for the sick, until desquamation and subsidence of the catarrhal condition are complete.

Prevention.—This is a most difficult disease to handle, since the long period of incubation and the four days of infectiveness before the appearance of the rash render its conduct almost impossible. It is most important that the suspicious cases should be early isolated without waiting for the rash to appear. Infected clothes, bedroom, etc., should be properly disinfected. Application of carbolised oil or glycerin prevents the infection from being carried about by the air. Richardson and Connor successfully immunized six children, who have been definitely exposed, by intramuscular injection of immune

serum. The serum being prepared from convalescents from four to forty days after the appearance of the rash.

The following measures exercise considerable control over the spread of the disease :—

1. Compulsory notification.

2. Prompt notification to the sanitary authority by the schoolmaster of the occurrence of any case amongst the scholars, and by the sanitary authority to the schoolmaster of any case occurring in the homes of any of the scholars.

3. In case of any exceptional prevalence the school should be closed.

4. Removal to hospital of, at any rate, the earlier cases.

Tuberculosis

Tuberculosis is a chronic infectious disease caused by tubercle bacilli. This includes pulmonary phthisis, scrofula, lupus, meningitis, and tabes mesenterica. Men and all domesticated animals may suffer from tuberculosis. Goats are immune to this disease. The disease prevails equally in temperate and tropical climates, although it is comparatively rare in colder regions. It is worse in crowded localities and is less in highlands than in lowlands, and on the sea coast than in the interior—due perhaps to greater dryness and purity of the air and soil.

In the British army the death-rate is 0.17 per 1000, in the native army 0.52 per 1000, and in the jails 3.21 per 1000. The mortality has been steadily rising in Calcutta since the epidemic of influenza in 1918. In 1921 there were 2,208 deaths as against 2120 in 1920. During the period of 1913-17 the mortality fell from 2,196 to 1539, while during 1917-21 it has risen from 1539 to 2,208.

No race is exempt from the disease, but it is said that coloured races suffer most. Both sexes appear equally liable, but the rate of progress of the disease is apparently more rapid in females than in males. The purdah system is to a large extent responsible for the increased incidence of tuberculosis amongst women. It occurs in all ages, but is comparatively rare below 5 ; from 10 to 20 there

is a great increase, which becomes greater year by year till the latter age is reached. This is followed by a still greater increase during the decade from 20 to 30, and a decline in later years.

Tubercle bacilli have been found at birth in the calf of a tuberculous cow and also in the human fœtus. But the weight of evidence is in favour of the doctrine that direct transmission of tuberculosis from parent to offspring, while possible, is very infrequent.

Ætiology.—The bacillus is a minute organism 2 μ to 6 μ long. It is very thin, motionless, and rounded at the ends. It is stained by the Ziehl-Neelsen method and shows a beaded appearance—clear spots alternating with the stained parts. The bacilli are usually straight or often slightly incurved. They are aerobic and retain their vitality for a long time outside the body. They thrive at a temperature of 82° to 108° F., and outside the body their existence is only of a parasitic nature. They can live for about six months in a dry state, but are readily destroyed by boiling or by sunlight.

Koch maintained that human tuberculosis is different from bovine and that it is not transmissible to cattle. He further holds that bovine tuberculosis is not dangerous to man. This view, however, did not meet with general support, and the whole question was referred to a Royal Commission, and their report (1907) is as follows :

" There can be no doubt but that in a certain number of cases the tuberculosis occurring in the human subject, especially in children, is the direct result of the introduction into the human body of the bacillus of bovine tuberculosis ; and there also can be no doubt that in the majority at least of these cases the bacillus is introduced through cow's milk. Cow's milk containing bovine tubercle bacilli is clearly a cause of tuberculosis and of fatal tuberculosis in man."

Modes of Infection.—1. *Inhalation.*—The bacilli leave the human body mainly in the sputum, and from the point of view of prevention expectoration should be regarded as a great source of danger in most cases. The bacilli also leave the body through other discharges. Thus

the fæces and urine, in cases of tuberculosis of the intestine and genito-urinary tract respectively, as also the discharges from any tuberculous ulcers contain the bacilli.

Dried sputum on handkerchiefs, clothing, bedding, walls, floors, etc., is often carried about by wind in the form of dust, and constitutes the most fertile source of infection. The likelihood of infection is greater in proportion as persons are dirty or careless in respect of the disposal of discharges. Cornet and others have in fact demonstrated living organisms in the dust and open objects of rooms where tuberculosis patients lived or were careless with their sputum. In other words pulmonary tuberculosis has been regarded as an air-borne disease, although some appear to think that this sort of infection has no practical value, and hold that although dust under certain conditions may contain the germs, they die when exposed to the sun and air. Indeed the dust of the open air rarely contains living bacilli ; and even if they do survive, the dilution is enormous. But the organisms remain alive for a long time in dark and moist places ; and a dusty atmosphere although may be free from the specific bacilli is exceedingly dangerous inasmuch as it irritates the mucous membrane of the nasal passages and opens the door for infection.

Although the disease is not now regarded as air-borne in the strict sense of the term, it has been pointed out that speaking, coughing, sneezing and other expiratory efforts often allow the contents of the mouth to be sprayed in the air in minute particles. These particles may contain the germs of any infection that may be in the mouth. When a person is suffering from pulmonary tuberculosis these *droplets* contain the bacilli in a virulent form. This sort of "droplet infection" is possible in close association with the patient in ill-ventilated rooms and does not take place if proper precaution is taken during coughing and sneezing (*See* p. 384).

(*b*) *Ingestion.*—Some cases of tuberculosis, especially in children, occur by the bacilli gaining entrance through the alimentary canal. It has been definitely proved that the tubercle bacilli taken with food and drink may

produce lesions in distant parts of the body and leave no trace of its passage in its wake. The conclusions arrived at by the Royal Commission to inquire into the relations of the human and bovine tuberculosis are : "A very considerable amount of disease and loss of life especially among the young must be attributed to the consumption of cow's milk containing tubercle bacilli. The presence of tubercle bacilli in cow's milk can be detected though with some difficulty if proper means be adopted and such milk ought never to be used as food. There is far less difficulty in recognising clinically that a cow is distinctly suffering from tuberculosis in which case she may be yielding tuberculous milk. The milk coming from such a cow ought not to form part of human food, and indeed ought not to be used as food at all."

Similarly infected meat may also be responsible for ingestion tuberculosis.

The presence of tuberculosis in cattle is ascertained by the *tuberculin test* which consists in injecting a small quantity of the glycerin extract of pure cultures of tubercle bacilli. If the cow is a tuberculous one, it will produce fever and a marked local inflammation in the neighbourhood of the tubercular foci.

The following conclusion has been drawn by the first Royal Commission on Tuberculosis :—

" Ordinary processes of cooking applied to meat which has got contaminated on its surface are properly sufficient to destroy the harmful quality. They would not avail to render wholesome any piece of meat that contained tuberculous matter in its deeper parts."

Besides the above certain factors predispose a person to tuberculosis ; they are chiefly impure air, overcrowding, damp soil, and insufficient food. Impure air and overcrowding are a constant factor of town life, especially with the poor. Persons living in ill-ventilated damp rooms and on a diet deficient in protein elements are more susceptible to tuberculosis. This is what usually happens with the poor who live in *bustees*. When the houses are built on the vicious system known as " back to back," impurity of air is inevitable which no doubt predisposes the occu-

pants to tuberculosis. Adenoids, or enlarged tonsils, or enlarged turbinates cut off fresh air and are predisposing factors.

Prevention.—The prevention of tuberculosis depends on the fact that without the tubercle bacillus there can be no tuberculosis. The bacillus must therefore be either destroyed or rendered innocuous. The general characters and life history of the bacillus indicate that sunlight and fresh air are inimical to its growth. As the disease is chiefly propagated by the carriage of the bacillus from an affected to an unaffected individual the secretions and excretions of the former require careful attention. The precautions may more conveniently be considered under the following heads :—

A. *Public Measures.*—Considering the high rate of mortality from pulmonary tuberculosis and the frequency with which the disease attacks persons of working ages and the long duration of illness it is important that every community, large or small, should be made to understand the significance of preventive measures, which include improved general sanitation. The public should be informed by every means that tuberculosis is a preventable and often a curable disease, and should be impressed with the importance of light and air. They should understand that well-devised measures for the increase of light and air throughout the town are worth spending money on. There should be ample open spaces, gardens, and parks in and near to all congested localities. Factories, lodging houses, offices, and places of assembly should be regularly inspected, and in all such places provision should be made for the reception of sputa. Indiscriminate spitting in the streets, public places, conveyances, etc., should be forbidden by law. It is high time that such expectorations should be considered as "nuisance."

It is also desirable that the public should be informed in simple but definite fashion regarding tuberculosis and its prevention. Provision should be made in all asylums, jails, cantonments, etc., for the separation and suitable treatment of patients suffering from tuberculosis. The possibility of the introduction of the disease through milk

and meat should not be lost sight of; and all dairies and slaughter houses should be examined periodically and all suspected animals seized or confiscated.

B. *Private Measures.*—Every one should be impressed with the fact that consumption is not contracted by exposure to "cold" simply. Light and air increase the resisting power of the cells of the respiratory organs. Bedrooms, sitting-rooms, assembly rooms, etc., should be kept open, and the more widely the better. Delicate children should undergo suitable lung gymnastics; these must be directed towards the production of a healthy form of chest and the correction of any existing structural deformity. The more the individual is in the open air the less risk is there of contracting the disease.

The consumptive should not sleep in the same bed with another and if possible not even in the same room. He should not, as a rule, marry. A consumptive should avoid kissing, and a consumptive mother should not suckle. Infection may be prevented from being carried into other parts of the body by insisting on the patient not to swallow the expectoration. Whenever possible a consumptive should change his occupation. If he has a sedentary habit and indoor life he must exchange it for outdoor occupation even at the risk of reduction of his income.

The patient should expectorate in a vessel containing carbolic acid lotion or other disinfectant. The vessel should be changed as often as possible and every time cleaned and washed with boiling water. The contents should be poured down the water closets or cremated along with soiled rags. Rooms occupied by consumptives should be carefully disinfected. In all suspected cases bacteriological examination of the sputum should be made in order that general prophylactic measures may be taken early.

The following precautionary advice is given to consumptive patients in Brighton:

Precautions for Consumpitve Persons

Consumption is, to a limited extent, an infectious disease. It is spread chiefly by inhaling the expectora-

tions (spit) of patients which has been allowed to become dry and float about the room as dust.

Do not spit except into receptacles, the contents of which are to be destroyed before they become dry. If this simple precaution is taken, there is practically no danger of infection. The breath of consumptive persons is free from infection.

The following detailed rules will be found useful, both to the consumptive and to his friends :—

1. Expectoration indoors should be received into small paper bags and afterwards **burnt.**

2. Expectoration out of doors should be received into a suitable bottle, to be afterwards washed out with **boiling water** ; or into a small paper handkerchief, which is afterwards **burnt.**

3. If ordinary handkerchiefs are ever used for expectoration, they should be **put into boiling water before they have time to become dry** ; or into a solution of a disinfectant, as directed by the doctor.

4. **Wet** cleansing of rooms, particularly of bedrooms occupied by sick persons, should be substituted for "dusting" and sweeping.

5. **Sunlight and fresh air** are the greatest enemies of infection. Every patient should sleep with his bedroom window **open** top and bottom, a screen being arranged, if necessary, to prevent direct draught ; and, if possible, occupy a separate bedroom. The patient need not fear going out of doors in any weather, if warmly clad.

N.B.—The patient **himself** is the **greatest gainer** by the above precautions, as his recovery is retarded and frequently prevented by renewed infection derived from his own expectoration.

6. Persons in good health have little reason to fear the infection of consumption. Over-fatigue, intemperance, bad air, dusty occupations, and dirty rooms favour consumption.

The excellent results obtained from the treatment of tuberculous cases in suitable sanatoria is now a settled fact, and it is necessary to secure for the public the advantages of sanatorium treatment. In India there are two

such sanatoria—one at *Dharampur* near Simla, and the other at *Bhowali* near Nainital. Apart from the curative effect of the sanatoria they have the advantage of segregating the patients, a most important preventive measure in this as also in other communicable diseases.

Tuberculosis dispensaries should be established in important centres. These will help diagnosis and treatment, and from a preventive point of view teaching the consumptives on the ways to take care of themselves. Much social service work can be done from these dispensaries.

In places like Calcutta where the disease is common it is necessary that the room in which a patient suffering from tuberculosis lived or died should be thoroughly disinfected. This is absolutely neglected at present with the result that the bacilli harbour in the infected room and are carried about with the dust and infect others. The room, in fact the entire house, should be lime washed and the doors and windows painted. But in all cases the room must be thoroughly and entirely disinfected. The walls, the ceiling and the floor should first be carefully dusted with a brush or cloth soaked in perchloride solution. This procedure will prevent the infected dust from being blown about. The room should then be freely and thoroughly washed with some disinfectant solution or fumigated with formalin vapour. All clothes, bedding, etc., should better be burnt, otherwise disinfected by steam. Similarly, rags, handkerchiefs, soiled by the patient should also be destroyed by fire. Privies, bathroom, etc., require the same attention as these are often spoiled by expectorations, etc.

Beriberi and Epidemic Dropsy

Beriberi is a specific form of multiple peripheral neuritis characterised by special liability to the implication of the pneumogastric nerves, and a liability to œdema of the connective tissues and to effusion in the serous cavities. The name is probably derived from the Singalese word "beri" meaning weakness; beriberi signifying great weak-

ness. It occurs endemically, or as an epidemic in tropical and sub-tropical countries, ships, asylums, etc.

Distribution.—It is endemic in the Far East and is a scourge in Malay and Eastern Archipelago. It is common in China, Japan, India and the Philippines, and also amongst the Chinese wherever they live in large numbers. The Chinese of Calcutta are equally liable to this disease. In short the disease prevails whenever man eats polished rice.

Ætiology.—Beriberi attacks both sexes and is rare in the two extremes of life. It affects both the rich and the poor—the former being more commonly attacked. It is common in prisons, asylums, and such other place where people are confined indoors. In the Malay States it is very prevalent amongst the miners. Although epidemics may occur at any time of the year, it is very common during the hot season, and in places where the temperature is hot all the year round it may appear at any time. The incidence of the disease is greatest amongst those whose diet chiefly consists of rice, although all rice-eating races are not affected.

Many theories have been put forward from time to time to explain the cause of beriberi, and it is only lately that anything like approximately accurate knowledge as to the *causa causans* of the disease has been attained. The first view is that the neuritis is due to deficiency of food or of certain known essential ingredients of food, *i.e.* starvation or partial starvation. This view has been strongly advocated by some Japanese authorities, especially Takaki, who considers the essential cause of the disease to be insufficient nitrogenous food—"nitrogen starvation." The second is that some unknown essential for the proper nutrition of the nerve is absent from the dietary and that this essential when withheld long enough results in nerve degeneration. According to this hypothesis beriberi is due to the absence of some essential in the food which is only required if rice be the main article of diet.

The observations of Fraser and Stanton go to prove that the neuritis in beriberi is due to the deficiency of a substance residing in the outer layer of rice called

vitamin, which is removed during polishing. This substance is rich in phosphorus, but the antineuritic property does not depend on the presence of phosphorus, inasmuch as this property is not diminished even after the removal of the phosphorus or phosphorus containing substance. It has also been found that if a pigeon is fed on polished rice alone it suffers from symptoms of beriberi, *i.e.* shows signs of neuritis, loses weight, and if this diet is persisted in it dies with all the signs of multiple neuritis. But if a small dose of vitamin or some of the polishings of the rice, *i.e.*, the dust or remains of the pericarp which had been removed in the process of milling be given, it will gradually lose the signs of neuritis, gain in weight and recover.

Acting on these observations the use of white or polished rice in jails, asylums, schools and hospitals has been strictly forbidden in Singapur and other places with the result that beriberi which hitherto had been the cause of enormous mortality has been practically banished from these institutions.

It is possible, as suggested by Daniels, that the causes of beriberi may be many, and that the cases of general neuritis at present included under this head are due to several causes, and should be sub-divided accordingly, and that there is not only one, but that there are many forms of nerve degeneration included under the term beriberi.

Although deficiency of certain accessory food factors is the essential etiological agent in the genesis of beriberi yet the infections and parasitic agencies cannot entirely be ignored. There are a number of cases which cannot be accounted for as due to the absence of certain accessory food factors only, and without the possibility of infection their occurrence cannot be explained.

The condition known as **epidemic dropsy** is only another phase of beriberi, although some still seem to hold it to be a different clinical entity.

Epidemic dropsy is characterised by œdema and anæmia, and preceded in most cases by gastro-intestinal disturbance, fever, and irritation of the skin. It often occurs in epidemic form, death being sudden, often due to œdema

of the lungs and cardiac complications. The sudden onset of the disease and the gastro-intestinal symptoms which frequently precede the attacks are much more suggestive of intoxication than of a food deficiency. Furthermore instances are not wanting when a healthy person shows definite symptoms of the disease within a few days of his arrival in the affected area and whose diets can in no way be considered deficient in any of the different accessory food factors.

The first systematic account of epidemic dropsy was by Col. K. MacLeod, based on the disease which appeared in Calcutta in the cold weather of 1877-78, 1878-79, and 1879-80. It broke out in Shillong and Assam in 1878 and at Dacca in 1879. It was carried to Mauritius in the cold weather of 1878 where it prevailed until 1879. Lovell published an account of this disease as seen in Mauritius and claimed that it was not contagious.

Stray cases were reported in 1907 and 1908, and in the year 1909 it occurred in an epidemic form in Calcutta. Greig showed that the incidence of epidemic dropsy coincided with periods of high food prices and famine conditions. He found no causative organisms in the fluids or tissues of the patients.

Ætiology.—*Age and Sex.* Both sexes are affected, though the incidence is greater among the females. The majority of cases occur between the ages of 20 and 40. Children and old people are less affected.

Race.—The Hindus, Mahommedans, and Indian Christians are all affected. It is comparatively less among Eurasians, and still less among Europeans.

The deaths in the epidemic of 1909 was 433 of which 283 were among females. It diminished in subsequent years, in 1910 it came down to 171, and in 1911 to 20 only.

Greig, after a careful study of the epidemic of 1909, came to the conclusion that no *causa morbi* is to be found in the blood, œdematous fluid, etc., of these cases. The disease closely resembles ship beriberi or war œdema and is a nutritional disease due to " one-sidedness " of the dietary of the people affected. In other words it is

supposed to be due to want of certain accessory food factors or vitamins.

Prevention.— Whatever may be the true cause of the disease certain preventive measures have already proved to be highly effective. As soon as the disease breaks out in institutions like asylums, jails, schools, the whole place, if possible, or at least the infected quarters, should be vacated, and not reoccupied till they have been thoroughly cleaned and disinfected. Thorough ventilation should be enforced and overcrowding as far as possible avoided. The ration should be revised and where rice is the staple food it should either be excluded or considerably reduced and substituted by meat, peas, beans, wheat, and milk, *i.e.*, substances rich in antineuritic vitamin. Polished rice should be entirely stopped. In asylums or jails, where there is a possiblity of its breaking out, the knee jerks should be tested and legs examined for œdema and hypersensitiveness, ana any suspicious case isolated at once. Marmite or yeast extract, wheat atta and ground nut (arachis nut) are rich in anti-beriberi vitamin, and their use in the diet is not only an efficient prophylactic but a valuable remedy in the treatment of beriberi.

Summary of preventive measures :—

1. The rice should be fresh parboiled.
2. It should be stored only for a short time in well ventilated and dry places. The old stock should not be mixed with the fresh one. In the form of paddy it can be kept for a long time without being infected.
3. If the disease appears, the supply of rice should be regarded as unfit for use. The store-house or other receptacles where the rice was kept should be considered as infected and likely to contaminate any fresh rice.
4. In an outbreak not only those affected, but also the people of the house should stop taking rice.
5. Diets rich in vitamin B., *e.g.*, eggs, meat, dal, fresh vegetables are of special value.
6. The diet should be healthy and a sufficient supply of fresh proteins, fats, vitamins and phosphorus are essential.

Rabies

Rabies or hydrophobia is an acute, specific disease communicated from a rabid animal to a susceptible animal, usually through a wound produced by biting.

Ætiology.—Although all mammals are susceptible to rabies, it is generally contracted by man from some domestic animals, usually dog. Some of the worst cases of hydrophobia in India are due to the bites of mad jackals. The infection is usually conveyed by means of bite, and as the specific poison is contained in the saliva of animals suffering from the disease, infection may be conveyed by simple licking, should there be any fissure or abrasion on the skin.

Rabies exists practically all over the world, but it has been stamped out by strict regulation in England. In India where every village is overrun by large numbers of unowned pariah dogs and where jackals abound the question of reducing their number will be evident from the figures of the Pasteur Institute at Kasauli, where 17,500 people were treated during the period 1902 to 1912, and of these about 15,000 cases were from bites of dogs, and 2500 by jackals ; the remaining cases being due to bites by horses, cats, cows, etc. The above, however, is not by any means the exact figure showing the actual number of cases, as the poor and the uneducated hardly ever avail themselves of the Institute, but have recourse to local indigenous treatment.

Seat of Virus.—At the autopsy of the man or animal died of rabies the virus is always found in the brain, medulla, cord, and the peripheral nerves. It is also present in the salivary glands whence it passes to saliva. The presence of the virus in the saliva greatly depends on the site of the inoculation. If the dog is inoculated in the eye the saliva becomes virulent three days before the appearance of the actual symptoms of the rabies. Once the symptoms have set in, the animal rarely lives longer than ten days. It is important to note that if the animal lives more than one week after biting a man the saliva at the time of the bite cannot have contained the poison.

Incubation Period.—This is extremely variable. The average period is as follows: Man, forty days; dog, twenty-one to forty days; horse, twenty-eight to sixty days. The incubation period depends upon

1. Site of the wound.
2. Relation of the nerve.
3. Amount of the virulence of the virus.

It is probable that the long period of incubation is due in part to the fact that the living principle reaches the central nervous system, but remains dormant until favourable conditions help multiplication and the production of toxic effect (Joseph Koch).

Prophylaxis.—This may be considered under three heads:

1. Treatment of wounds.
2. Control of disease in dogs.
3. Pasteur prophylactic treatment.

1. *Treatment of Wounds.*—The wound should be thoroughly washed, dried, and then carefully cauterised as soon as possible after the infection. Each separate tooth-mark should be touched with either pure nitric acid or carbolic acid, or, in the absence of either, with permanganate of potash. The acid is best applied with a glass rod, care being taken that the pockets and recesses do not scape. Cauterisation, however, should not be considered as absolutely safe, but if carefully applied it destroys a considerable portion of the poison, and thus gives the Pasteur treatment a better chance of success.

2. *Control of Disease in Dogs.*—This is attained by muzzling and quarantine of dogs, and is by far the best method of preventing and exterminating the disease. In England the disease entirely disappeared with the introduction of compulsory muzzling and quarantine for six months of all imported dogs. Besides these the following additional measures may be adopted to control the dog question: (*a*) destruction of all ownerless dogs; (*b*) owner held legally responsible for damage inflicted by their dogs; (*c*) compulsory notification of all cases of suspected rabies.

3. *Pasteur Prophylactic Treatment.*—The object of Pasteur treatment is to secure active immunity against the

disease by gradually increasing the doses of the rabies poison into the patient during the long interval that usually intervenes between the bite of rabid animal and the development of the symptoms of hydrophobia. Unless perfect immunity can be secured during the incubation period the treatment will fail. It is useless when once the symptoms have developed. No time should therefore be lost in sending the patient to the Pasteur Institute at Kasauli, Coonoor, or Shillong. The modified procedure recommended by Semple at Kasauli is to make an 8 per cent. dilution of the medullas of rabbits which have died after inoculation with rabies, in normal salt solution to which 1 per cent. carbolic has been added. This is kept for twenty-four hours at 37° C.; then diluted with equal volumes of sterile normal salt solution and stored in a cool place away from light. Thus the vaccine is a 4 per cent. dilution with 0.5 per cent. carbolic.

Diagnosis of Rabies in Dogs.—This may be done in three ways:

1. From the symptoms.
2. From the presence of Negri bodies.
3. By animal inoculation.

1. The course of the disease may be divided into three stages: premonitory stage; stage of excitement and paralytic stage. The first two stages may be transient or absent, when it is generally known as "dumb or paralytic rabies." The first symptom noticeable is the change in the disposition of the animal. It is easily excited and becomes restless and subsequently may become furious and even show signs of delirium. It rushes about attacking every object, and dogs suffering from furious rabies often run long distances (20 miles or more) biting and inoculating men and animals on the way. Paralysis, however, very soon sets in, first starting on the hind legs and then becoming general. The course of the disease is always rapid, from four to five days, rarely exceeding ten days.

2. The presence of Negri bodies in the brain of the rabid dogs is constant and is considered as practically conclusive evidence of the existence of rabies. These

bodies should always be searched for. In the search for Negri bodies the following rules should be observed :

(*a*) Do not kill the animal immediately after it bites the victim, but keep it under observation for ten days. If it remains healthy, this is absolute proof that the animal was not suffering from rabies. If, however, the animal shows signs of illness either allow it to die naturally, or kill after three or four days.

(*b*) Do not shoot the animal in the head. Remember if the brain is destroyed, or blown out, or badly damaged it may render satisfactory examination impossible.

(*c*) Send the whole head to the laboratory well packed in ice.

2. The diagnosis by inoculation test has been given up in favour of the foregoing methods, as this requires so much time (owing to the long period of incubation) that it is of no practical value in deciding whether or not the Pasteur treatment should be adopted.

Influenza

Definition.—An acute specific infectious disease characterised by fever, with symptoms affecting mainly respiratory, digestive, and nervous systems, and by severe prostration.

History.—Every quarter of the globe has been the scene of visitations of epidemic influenza. The first appearance of the disease in Spain caused it to be known as " Spanish influenza " in contrast with the " Russian influenza " of previous epidemics. During 1918 an exceptionally widespread epidemic appeared, which affected the inhabitants of practically every continent. This epidemic not only caused directly or indirectly, a very large number of deaths which in India alone were computed to exceed five millions, but left behind it a legacy of minor ailments with consequent national debility.

Although previously severe and world-wide epidemics have been known to occur, in none were the spread and mortality so alarming as in the epidemic of 1918. Small localized epidemics have occurred and sporadic cases have continued throughout the year 1919 and 1920.

Ætiology.—The organism responsible for the epidemic of influenza has not been definitely identified. The weight of evidence still points, however, to the bacillus, called the *bacillus of Pfeiffer* being the cause ; at all events it is intimately associated with the disease. Judging from clinical and epidemiological standpoints, the disease which appeared in India was identical with the last great pandemic of influenza which occurred in 1890-91. Pfeiffer's bacillus, the pneumococcus, and the streptococcus, seem to be responsible for most of the fatal complications of influenza.

Influenza is a disease which exhibits an intense infectivity, and an incubation period which is relatively very short, *i.e.*, from 6 to 48 hours. It is commonly believed that the disease is spread by the infected secretions of the throat and nose of infected persons finding lodgment in the nose and throat of uninfected people. The commonest means by which this occurs is by coughing and sneezing, especially in confined spaces.

Prevention.—A. *Education of the Public with regard to the following* :—

1. Avoid infection as much as possible.

2. Cultivate healthy and regular habits, take regular exercise, eat good food, and avoid fatigue, chill and alcoholism. Healthy living makes the patient better able to withstand the complications which may be fatal.

3. It is most infectious in the earliest stages ; and coughing, sneezing, spitting and hawking in public places are dangerous.

4. It is not always possible to avoid infection, but the risk can be lessened by

(*a*) working and sleeping in well-ventilated rooms ;
(*b*) avoiding crowded gatherings and close ill-ventilated buildings, or carriages ;
(*c*) wearing warm clothing ;
(*d*) irrigating the nose with saline solution ;
(*e*) wearing in certain instances a mask of prescribed pattern.

5. Those attacked should

(*a*) either go to hospital, or go to bed and keep warm ;

(*b*) occupy, if possible, a separate bedroom or a bed that is screened off from the rest of the room ;

(*c*) not return to work, until convalescence is well established, and during convalescence should be extremely careful to avoid chill which may induce a relapse or complications ;

(*d*) avoid meetings and places of entertainment for at least one week after the temperature has become normal.

B. *The Closing of Schools, Cinema Halls, etc.*—Regarding these measures universal recommendations cannot be made. The widespread depression in the minds of the general population during epidemic times must be remembered. Such depression may be a predisposing factor in the occurrence of the disease, and it is felt that if measures were passed such as closing all theatres and resorts of amusement, the effect on the public health might be worse than if nothing was done at all.

As regards closing of schools it should be remembered that if children were taken from well ventilated schools they might add to the congestion of already overcrowded houses. This matter must be left to individual localities to settle, bearing in mind that it is necessary to limit the number of unnecessary gatherings and that it is necessary to keep up the morale of the public. In this connection attention should be drawn to the dangers associated with travelling in cars and carriages. It is believed that a fertile source of the spread of infection occurs in overcrowded railway carriages, tram cars, etc. The prevention of overcrowding should especially be insisted on at such times and scrupulous cleanliness of carriages and cars be enforced.

C. *The Wearing of Face Masks.*—Opinions are divided as to the efficacy of this measure, it largely depends upon their construction. The masks should be of very close woven muslin or gauze. Recent work in America would seem to point to a gauze with a mesh 44 by 40 to the inch ; three to six layers of fine muslin should form the mask and they should be applied so as to cover the

nose and mouth completely. The gauze is cut 8 inches wide and 23 inches long.

The use of these masks should be made compulsory among nurses and attendants in hospitals which admit influenza patients and might be adopted in houses where cases of influenza are present and among volunteers and others who come in contact with the sick.

Another suggested use of face masks is by barbers, dentists, etc., whose occupation brings them into close contact with a number of persons, and who if incubating the disease may otherwise infect their clients.

D. *Isolation.*—Insistence upon isolation of influenza cases in India is impossible. Every case, however, of influenzal pneumonia should be rigorously isolated as the germs present in post-influenzal pneumonia are themselves infectious, altogether apart from the causative organisms of influenza. Hospitals should attempt to separate uncomplicated influenzal cases from those suffering from secondary pneumonia.

E. *Sprays and Gargles.*—The use of disinfectant sprays and gargles is not recommended. Disinfectants are apt to remove the protective mucus of the throat and mouth ; to cause irritation of the mucous membranes or lining membranes of these cavities and so predispose to the lodgment of infective material. They can hardly be used strong enough to be protective without causing violent irritation.

The use, however, of a solution of common salt one teaspoonful to a pint or 20 ozs. might be productive of good results if used as a gargle or sniffed up the nose, as it will produce an excess of the normal secretions of the nose and throat and thus lead to the washing out of micro-organisms. The Royal College of Physicians recommends 20 drops of Liquor Sodæ Chlorinatæ in a tumbler of warm water to be used as a gargle at least twice a day.

F. *Disinfection.*—With regard to the disinfection of infected rooms, it seems fairly established that ordinary cleansing with water, airing and sunning effect as much good as the use of actual disinfectants. All handkerchiefs, sheets and clothings, recently soiled (within 48

hours, as drying kills the infective agent) should be boiled or otherwise sterilised.

The periodic disinfection on the above lines of public places, *e.g.*, railway waiting-rooms, trams, rolling-stock, dak-bungalows, *serais*, etc., which in epidemic times may be taken to be infected, is also strongly recommended.

G. *Quarantine.*—A limited measure might be practised by local institutions such as resident colleges, schools, asylums and jails. A jail, for example, situated in an epidemic area might by rigid quarantine be reasonably certain of keeping out infection, or at least of delaying its appearance.

H. *Prophylactic Vaccination.*—A mixed vaccine of the following composition and doses was recommended by the War Office Committee :

	First dose	Second dose
B. influenzæ	30 million	60 million
Pneumococcus	100 ,,	200 ,,
Streptococcus	40 ,,	80 ,,

Leprosy

A chronic infective granulomatous disease produced by a specific bacillus and characterized by diseases of the skin, nerves, and viscera leading to local anæsthesia, ulceration and other trophic lesions.

History.—The disease is of great antiquity and there is some evidence that it is of comparatively recent introduction into Europe, possibly it was imported from Egypt. The 1st allusion of the disease in England refers to about the year 950. Very soon after leprosy began to decline in Europe it spread to the West Indies, northern part of South America and Mexico, being carried by infected Portugese and Spanish invaders, and later by Negro slaves and Chinese and Indian immigrants. It is interesting to note that the aboroginal American Indians are free from leprosy. The whole evidence shows that leprosy is a communicable disease creeping slowly over the whole world.

Nearly all the countries with the highest incidence of leprosy are situated in humid, hot tropical areas of Africa, Asia and America.

The evidence of the existence of leprosy in India in remote periods is of a more definite character. Reference is made to leprosy in the 14th and 16th century B.C. and facts are accumulating to show that the disease found its way to Greece through Asia Minor.

Leprosy now is more or less a disease of the tropical and sub-tropical countries, and with the exception of a few insignificant islands it appears to be an important factor in the pathology of nearly all warm climates.

Heider estimated the lepers of the world at about two millions. The census of 1921 estimated 102,513 lepers in India with atleast an equal number of earlier unrecorded cases. There are about 18,000 in Bengal and 1000 in Calcutta. But these figures may be an underestimation owing to the fact that many cases are not properly diagnosed or perhaps concealed. There are a considerable number of lepers in the Cape, a few in Australia and in San Francisco.

The disease has been recently introduced in certain virgin soils. For instance in Sandwich Islands it was unknown before 1848, and in New Caledonia until 1865.

Ætiology.—The lesions are the result, direct or indirect, of the proliferation of the *B. lepræ* in the tissues. This bacillus closely resembles tubercle bacillus in retaining carbol fuchsine stain after being treated with acid. The bacillus is found in all primary leprous deposit, in the skin leproma, in the macular eruptions, in the specific lesions of the liver, spleen, testes, lymphatic glands and lungs. It is abundant in the purulent discharges from nose, ulcers and other forms of primary leprous infiltration. It is not found in muscle, in bone, or in cartilage.

Since leprosy is caused by a specific bacillus it is safe to infer that there must have been a time in the history of every leper when the infecting germ entered the body.

The exact manner in which the organism infects the healthy is still obscure, although general consensus

of opinion is that it enters through minute lesions of the skin or superficial mucous membrane, specially the nasal passage; and that prolonged exposure or close contact with a leper is usually necessary before infection takes place. But no initial lesion has so far been described by any observer, nor anything to indicate precisely the seat or the time of infection.

The leprosy bacillus leaves man in the nasal discharges, and in the discharges from ulcerations where lepromata are exposed. Blood-sucking insects feeding on superficial lepromata take up the bacillus. Non-biting flies can also carry the bacilli from ulcers and discharges.

Bed-bugs have been found to harbour the bacilli and capable of transmitting the disease in animals. They may prove to be one of the factors in the transmission of the disease.

The history of the disease in all countries and among any class of people points to the certainty of contagion. In New Caledonia the spread of the disease from individual to individual, and from place to place, can be, and has been, traced. The course of the disease has been progressive when segregation has not been enforced and retrogressive when it has.

Various speculations as to its conveyance by food, or being caused by certain special articles of food have been made. Sir Jonathan Hutchinson strongly advocated the theory of its relationship with the fish, especially of dried fish. On the other hand, leprosy is not unknown in communities that do not use dried fish, or any sort of fish at all. Indeed it is difficult to understand how fish in any form can cause the invasion of the body by a bacillus which has not been found to be present in the fish.

The opinion generally prevails among physicians in some places that leprosy is frequently communicated by sexual intercourse.

The theory of heredity is now universally discredited; the younger the person at risk the more susceptible he is. The most of the so-called hereditary cases are cases where

the infection has been acquired by the children of lepers owing to their repeated exposure to infection after birth; and it is believed that the disease has been acquired by contagion from the parents and not by descent.

The history of the disease shows that it is conveyed from man to man. Its long period of incubation and slow development are obstacles to the discovery of the means by which infection is propagated. In India where people walk barefoot, the disease begins in the feet in one-half of the cases, the presumption being the bacillus are contained in the soil in which they have been deposited by leprous discharges.

Certain conditions favour the spread of the disease. They are (*a*) overcrowding, as happens in the streets of Calcutta; (*b*) sociability and overcrowding at festivals; (*c*) absence in certain places of all fears of the disease, and tolerence of lepers in the community; (*d*) sexual promiscuity; and (*e*) using the same utensils for food, and smoking the common hookah or pipe.

Prophylaxis.—Despite the findings of the Indian Leprosy Commission of 1891 it is now well established that leprosy is a communicable disease. The first essential in propnylaxis is the removal of infectious cases from frequent and close contact with the nealthy, especially children and young persons between 20 to 30 years. Cases are on record where contact with lepers, or their clothing, caused tne disease. Three classes of lepers are to be found in big cities:

1. Indigenous lepers who develop the disease without any taint on their ancestors.
2. Children born of lepers.
3. Pauper lepers, who migrate to cities where they find it easier to make a living.

Isolation and segregation with compulsory notification have in many instances diminished the number of cases whenever they were rigidy carried out. A strict census should be taken of all lepers in cities, whether pauper or not, and their addresses registered. They should be forced under penalty, to live within certain specified areas and strict guard should be kept to prevent their

escape, and mixing with the general public. The present "Leper Act" of India is not quite effective, since it does not enforce rigid segregation of the lepers who are a menace to the community. There are however certain practical difficulties in adopting any stringent measures which have to be overcome; difficulties arising from the rights of the individual, financial difficulties, and those arising from concealment and incorrect diagnosis. Fresh cases may be imported and these may add to the difficulties in complete and thorough segregation. A modified system of segregation and isolation may be introduced. Lepers should not be allowed to beg in the street, or to keep shops, to handle food and clothing, and to wander about the country as mendicants, neither should they be allowed to work as domestic servants.

An ideal arrangement would be to classify the lepers in each province and segregate them by establishing "leper colonies" or "leper settlements." These colonies or settlements should be self-contained with shops and bazars, places for recreation, amusement and religious functions, befitting the different classes of lepers. They should be well housed and fed with liberty of movement within the colony. Here the lepers should be made happy and comfortable so that they will not be inclined to leave the proscribed area. In the colony the lepers should be utilized in different forms of labour, like farming, growing vegetables, keeping cows and poultries, etc. In fact all the work within the settlement should be done and managed by lepers themselves.

Pauper lepers should be isolated in leper homes or colonies. But these form comparatively small part of the total lepers in India. In fact an ordinary respectable citizen who conceals his disease and freely mixes in society is a greater danger than these pauper lepers.

The following precautions should be observed by all lepers :—

1. Live in separate rooms, use separate utensils and keep clothes separate, which should be boiled for half an hour before sending for washing.

2. They need better not use any public vehicles.

3. They should be cleanly in their habits and should avoid doing anything which may lead to dissemination of disease germs.

The following precautions should be observed by medical men who handle lepers :—

1. Wash the hands thoroughly, immediately after touching a leper or any article of lepers.

2. Whenever possible use rubber gloves when attending lepers.

3. In leper homes the highly infectious lepers should be kept separate from the less infective ones.

4. Those coming in contact with lepers should try to keep good health by means of abundant fresh air and light, exercise and nourishing food.

Anthrax

Anthrax is an infectious disease of animals, but transmissible to man, caused by *Bacillus anthracis*, which occurs in the blood of infected individuals, in the soil and various other materials after these have been contaminated. The disease may be local, when it is known as malignant pastule, or general.

The infection occurs in various ways. Thus cutaneous anthrax is formed by inoculation or contamination of open wounds, pulmonary anthrax or " wool sorters disease " by inhalation, and intestinal anthrax by ingestion. The last two varieties are generally known as internal anthrax.

Anthrax in lower animals.—Most of the domestic animals are liable to the disease and are infected in the same way as man. Sheep and goat are most susceptible animals to infection by inoculation or ingestion. Cattle are easily infected through the alimentary canal. Cold-blooded animals, birds, dogs and cats offer considerable resistance.

The discharges of the infected animals may contaminate the grass, and the spores under suitable conditions live for a long period. Healthy animals feeding on infected pasturage may become infected through abrasions or wounds in the mouth.

Ætiology.—The usual way in which man is infected is by direct inoculation, or by inhalation of dust containing spores giving rise to general infection. Infection is also common during killing or skinning diseased animals. The disease is specially common with those who deal in hides. Cases are also on record where the infection occurred by using infected shaving brushes. It has been suggested that the poison may be carried by flies and other insects.

Prevention.—1. Disinfection of horse-hair, hides and other substances liable to harbour the bacillus. Disinfection by steam however damages the skin.

2. Proper ventillation to carry off the dust.

3. Handling of bales, etc., should be reduced to a minimum, and the hands of the workmen should be free from abrasion and protected by gloves.

4. Hides should be soaked in a solution of 1 to 2 p.c. tannic acid and 1 in 200 of mercuric chloride. Bales of horse-hair are very difficult to disinfect as the steam will not penetrate pressed bales. Steam can be of use only when the horse-hair is spread out. Boiling for 30 minutes is quite useful.

5. All workers should thoroughly clean themselves before taking food.

6. All dust and residue in the hide godowns should be carefully collected and burnt.

7. Early diagnosis and use of Sclavo's serum are important.

CHAPTER XXI

MEDICAL INSPECTION OF SCHOOLS

THE progress of civilisation, the welfare of the individual, the general good of society are contingent upon the efficiency of the education imparted to the children in schools; and when it is remembered that from three to five hours daily of six days in the week for from seven to eight months in the year are obligatory for children and young lads, the importance of a careful sanitary oversight of schools becomes at once apparent. Unfortunately school hygiene is very much neglected in this country, although of late years some attempt in this direction has been made by the different Universities. Modern civilisation demands education on a wide scale, but this will yield no fruitful result unless the waste of health of the future parents from bad air, bad food, bad light, bad seating, overcrowding and mingling of the sick with the healthy, is prevented. Owing to the fact that a large proportion of recruits during the South African War had to be rejected for ailments of many kinds, the necessity of increased superintendence of physical growth became manifest, and a Royal Commission of Physical Training was appointed in 1903. The findings of the Commission were: (1) that many of the defects found in the recruiting stations had their origin in early life; (2) that physical training in schools could not be efficiently developed except under medical supervision; and (3) that even for the purpose of general education medical inspection of the school children was called for.

The objects aimed at in the medical inspection of schools are:—

(1) The detection of contagious diseases, thereby protecting the child and the community.

(2) The detection of physical defects which prevent the child from acquiring a full education with the least sacrifice to his physical welfare.

(3) To find the capacity of the individual pupil to acquire knowledge in accordance with his mental and physical status.

(4) To ensure the best possible hygienic surroundings for the child while he is at school.

(5) To bring about a close relationship between the school and the home so as to carry out more successfully the other ends of medical inspection, and ensure treatment of discovered defects.

(6) To teach the practice of hygiene and healthful living both in school and at home.

To accomplish these objects trained physicians are required. In places where it is impossible to command the services of the physician, the teacher, who must have some training, may act in the capacity of an examiner and refer suspicious cases to a physician. The medical inspector should be constantly alive to his responsibilities and always on the alert to remedy defects. For in childhood many conditions may be remedied or prevented that in adult life may seriously compromise the health and usefulness of the individual.

One medical inspector to every five thousand pupils is a fair average of the number of men required for the work in any city. The number, however, will also depend upon the amount of work to be done, as also upon the number of pupils in a school, the nature of the population, the probable defects found, and the system of inspection employed.

An examination of the health of about 2,000 students of Calcutta shows that, roughly speaking, only 33 per cent. are free from defects. That so large a percentage as 67 are defective in some way or other is a matter for serious consideration.

The school is generally regarded as the veritable source for the spread of infections amongst children, specially measles, whooping cough, mumps, diphtheria, chickenpox, etc. It is also important to note that apart from

the children who actually contract the disease, the infections are carried home which form further foci.

Qualifications of Inspectors.—Any competent, conscientious physician may be trained for the position of medical inspector. It is desirable to have a physician who has had previous training in the diagnosis of infectious and skin diseases and practical knowledge in examining the eye, ear, throat and nose.

The Scope and Nature of Medical Inspection.—An important part of medical inspection consists in the inspection of sanitation of school-buildings and grounds. One cannot teach hygiene and healthful living surrounded by insanitary buildings wherein classes are conducted. Attractive, well-situated, and well-kept school-rooms are in themselves an object-lesson, and an incentive for the pupils to try to live properly.

Twice a year—once in summer and once in winter—an inspection should be made, which should include every part of the building, including its drainage, water-supply, ventilation, cleanliness, etc. All insanitary conditions should be noted and a re-examination made after some time to see if these have been remedied.

The medical inspector should begin his work by thorough inspection of the grounds surrounding the school. The out-houses, water-closets and urinals, ventilation, cleanliness, condition of plumbing and drainage, and the number of seats in relation to the school attendance should be carefully noted. The kind and condition of school-grounds, the presence of stagnant water and overgrowth of vegetation should also be noted.

The building should be inspected for cleanliness, dampness of walls, presence of water, or accumulation of refuse. The inspection of class-rooms includes the measurement of each room and the amount of window space and lighting, and the kind of tables and benches used.

The water-supply is very important—the source and purity should be investigated where there is no filtered water-supply. The way the water is stored is equally important, and where filters are used they should be

examined for cleanliness, and to see if they are in working order.

The systematic examination of all pupils on admission should be made and results recorded in a schedule. Those who require special supervision during their school course, those to be exempted from gymnastics, and those requiring special position on account of defective sight and hearing should be noted. The schedule containing these details should accompany the child all through his school course. With regard to the "general constitution," the school inspector must state for each child whether his constitution is good, medium or bad. Every fortnight, and oftener if necessary, the school doctor should visit the school and examine systematically any cases brought to him and record his observations and instructions.

Duties of Medical Inspector.—

1. He shall advise as to new sites and plans of new schools; he shall exercise a general supervision over the ventilation, lighting and cleanliness of the school; he shall periodically inspect all school lavatories and other sanitary installations.

2. On receiving intimation of an outbreak of infectious disease among the pupils attending any school, he shall at once enquire into the outbreak and take such action as may be immediately necessary, and as soon as possible report the result of this enquiry to the Board.

3. He shall advise as to the necessity of periodic disinfection and cleanliness of the school with a view to the prevention of disease.

4. He shall make such examination as the Board may require as to the mental and physical condition of the children selected for special classes and grant any necessary certificate.

5. To the extent and in the form prescribed from time to time he shall examine the pupils attending the school, and shall preserve and maintain on an approved schedule a record of the examination of each child.

6. He shall from time to time inspect the physical exercise given in the schools.

7. If any child is reported as suffering from any ailment, or defect, or injury, he shall as soon as possible examine the child and give such direction as may be necessary.

8. He shall, by lectures, demonstrations or otherwise, instruct the teachers in the methods of recognising the common ailments and defects of school children ; in the practice of first aid for school accidents ; in the general hygiene of the school and class room, and in the physiological principles underlying physical training.

9. He shall keep such records and books as the authorities may prescribe or approve, and he shall submit an annual report on the work done, and make such special report as the executive head may require.

10. He shall make periodical visits to all the hostels attached to the schools and report on their sanitary condition, surroundings, cleanliness, and condition of dietary.

11. He shall insist on the schools and hostels being whitewashed and cleaned every six months or year.

Method of Inspecting Pupils.—The medical inspector should have a routine method of conducting physical examinations. As the child enters the room, the inspector notes his gait and in a low tone asks his name and age, and by the promptness or otherwise of the answer gets a rough idea of the condition of the hearing and sometimes of the mentality. He observes any abnormalities of structure, differences between the two sides of the body, facial expression, etc. He notes the colour of the skin, presence of jaundice, anæmia or any form of rash. The mouth and throat are next examined : the presence of an odour indicates uncleanliness of the mouth, carious teeth or naso-pharyngeal catarrh ; mouth-breathing or signs of nasal obstructions are also noted. Eyes are inspected for any inflammation, presence of strabismus or ptosis. After obtaining all the possible data, the hearing and vision should be examined in detail. The examination of the eyes should have special attention, as no other organ of the body bears a greater influence on the child's welfare. Children suffer-

ing from wordblindness, word-deafness, and moral imbecility demand special provision for education.

The following points should be noted in the schedule during the medical inspection of each child :

I. General Informations :

Name—age—sex—address—nationality.

Name of School—date of inspection—class.

Measurement—height—weight—nutrition—cleanliness—clothing

II. Personal History :

Previous illness (before admission) from infectious disease.

Vaccination—re-vaccination—family history (any thing special, *e.g.*, tuberculosis.)

III. Special Conditions :

Teeth—nose—throat (tonsils, adenoids, etc.)—eye—vision—ear—hearing—speech—mentality.

IV. Diseases or Deformities :

Heart—lungs—spleen—liver—skin—anæmia—malaria. Tuberculosis—rickets—special diseases and deformities (squint, talipes, harelip, stunted growth, deformed chest, etc.).

Medical Officer's Signature :

General Observations :

Directions to parents or teacher with regard to diet, exercise, hours of study, cleanliness, etc.

Action taken upon the Detection of a Case of Infectious Disease.—A pupil suffering from a contagious disease, whether latent or mild, should be immediately excluded from the school. The class attended by the infected child is then dismissed for the day, if the disease is diphtheria or small-pox, to enable the authorities to disinfect thoroughly. In cases of diphtheria, measles, mumps or whooping cough, the class should be inspected for more cases, and smears of the throat taken for diphtheria bacilli of the children seated nearest to the infected child. If the scholar is treated at home, the other children in the house must be excluded from school until the child recovers and the house disinfected. This precaution is

particularly necessary in cases of small-pox, cholera, measles, whooping-cough and diphtheria.

The school authorities should insist on the production of a medical certificate by the scholar during admission and also when he joins the school after a vacation. This should clearly mention occurrence or not of infectious disease either of the scholar or any member of the household within three weeks.

The following is a summary of regulations regarding the exclusion of children suffering from infectious diseases or living in the same house :

Diseases.	Exclusion of children infected	Exclusion of children living in the same house.
Cholera . ..	Until discharged from hospital or certified as free from infection.	Until after 7 days from the date certified by H. O that the house is free from infection.
Diphtheria .	2 to 4 weeks after discharge from hospital If treated at home same period supported by bacteriological examination.	Same as above, or 2 weeks or until bacteriological exam. shows negative results.
Measles	4 weeks.	*Over 7 years*—exclude for 3 weeks those who attend infant school, or who have not had the disease. *Infants*—21 days from date of onset of the last case.
Mumps	3 weeks.	3 weeks only those who have not had the disease.
Chicken-pox ..	Until scabs fall off.	Infants for 2 weeks.
Small.pox ..	Same as in cholera.	Same as in cholera
Tuberculosis ..	Exclude if accompanied by cough and expectoration.	Not to be excluded.
Whooping Cough ..	6 weeks or as long as cough remains.	2 weeks for all excepting those who had the disease.
Influenza ..	2 to 3 weeks.	10 days.

CONSTRUCTION OF SCHOOL BUILDINGS

The Building.—This must be in a healthy locality and convenient to get at ; it should not be near to railroads,

noisy factories, or mills. It should have ample open space.

The building proper should preferably be two-storied ; when space admits a school should contain, besides its class room and administrative offices, a common room, and a gymnasium. One room should be set apart for the work of the medical inspector.

The foundation must be impervious to water so as to prevent dampness. There should be some non-absorbent material—natural stone, hard-burnt brick (*jhama*), and an impervious or tarred lining between the foundation and the superstructure.

If there be a basement, it should be of sufficient height for light and air to penetrate every part of it, and should never be used as a store-house for refuse of any kind.

Sanitary Conveniences.—Ample provision must be made for privies and urinals, one set for each storey. The urinal should be constructed of slate or stone, properly flushed by constant running water. Closets and urinals should be sufficient to meet the demands of the number of students in the school. These should be in the proportion of 5 of each for every 100 students. They can be located outside the main building, or may be a detached portion connected with the main building by overhead bridges. In any case these should not be located too near the class room. Water-closets should be of such a nature as to allow of easy scrubbing and be provided with automatic flush. Arrangements must be made for a supply of water for washing purposes, and proper receptacles provided, which must be kept clean. In village schools privy arrangements must be made with all sanitary precautions and a sweeper engaged to keep the privy clean after each visit. The disposal of night-soil must be attended to. Special care should be taken to protect the well or the tank from being polluted by indiscriminate use through carelessness of the students and the servants. Where funds would permit installation of *septic tank latrines* should be done, as these are particularly useful and safe in the absence of water-carriage system. There

must be a separate washroom adjoining the bathroom, and children should be taught to use it for cleansing hands and face after play or a visit to the closet. If tap water is available, an ordinary porcelain basin with run-off to the sewer should be installed. In the absence of this, ordinary enamel basins with the water-supply in buckets should be provided for.

Water-Supply.--Special attention should be paid to the water-supply for drinking purposes. In villages where there is no public water-supply, the purity and suitability of water for drinking purposes must be carefully ascertained. The tank or the well should be inspected and a sample of water taken for chemical and bacteriological examination. If water is preserved in vessels, it must be under cleanly conditions, and steps taken to protect the water from contamination. The use of the same cup or glass by different individuals should be prevented, unless these can be cleansed each time after use. It is better to drink direct from the tap. In the United States of America special arrangements, fixed on to the taps, have been made for drinking purposes, which consist of small glass cups with an automatic cut-off, from which the child can drink without the lips touching the glass. A special tank or a deep well should be reserved for drinking purposes and properly guarded to prevent contamination. A deep tube-well with a hand-pump is quite convenient and useful. Where funds are not available the only way to avoid water-borne diseases amongst the scholars would be to have the water first clarified by the use of alum and then boiled and kept in clean vessels.

Class Rooms.--These should be large and cheerful. The minimum floor space for each pupil should be 15 sq. ft. Faulty lighting, ventilation, or sitting arrangements may directly cause many defects ; and the school inspector must see that school conditions are not responsible for any of the defects in children. Receptacles with carbolized sawdust or some antiseptic fluid should be placed in the class rooms and other places for spitting, etc. Students and teachers should be strictly warned against spitting indiscriminately anywhere

and everywhere, especially on the walls and in the corners.

Seats and Desks.—The most important articles of furniture from a sanitary point of view are the seats and desks. The seating arrangement is of great value inasmuch as faulty benches often give rise to certain orthopædic defects. In most schools the child is adjusted to the benches and the tables. In most of the seats it is impossible for the child to assume a comfortable and correct posture. Seats should be arranged parallel with one another and at right angles with the windows. Ordinarily desks should be 15 to 18 in. broad with a slope of 15° for writing and 45° for reading. The height of the child should be the only consideration for choosing desks and benches, and therefore adjustable ones are most suited. They should not be too high nor too low, too near or too far from each other. There must be sufficient room below the desk for the knees, and the desk should be low enough for the elbow and forearm to rest comfortably without bending the back. The feet should rest flat on the floor of the seat, which should not be wider than the hips, and the depth should be two-thirds the length of the hips. The construction of the back-rest is very important, and it should support the spine in the lumbar region in all positions. Any support above the hollow of the back is unnecessary and encourages the slouching position. The distance between the seat and the desk should be such that the scholar may read or write on it without leaning forward more than a little and without entirely losing the support of the back. It follows therefore that unless the desks and the benches are constructed with full regard to the above points there is possibility of defect in sight, injurious effects as to posture and wrong habits of carriage.

Posture.—Every care should be taken to prevent the scholar from acquiring physical defects in schools. Posture in sitting therefore is important. Too much stooping posture leads to myopia, contracts the chest and interferes with respiration. It puts an extra strain on the heart, and causes curvature of the spine.

Ventilation.—Class rooms must be freely ventilated; pure air has an important bearing on the health and vitality of the pupils. The air may become vitiated by the respiration of the students and teachers, by the fermentation and putrefaction of animal or vegetable organic matter, by dry excreta, dust from chalk, blackboard, wear of floors, and dirt from shoes. Germs of communicable diseases located in the respiratory tract of the students are added to the exhaled matter. These germs and dust particles adhere to the moist mucous membrane of the respiratory tract, throat and mouth, and may later reach the lungs, if not removed by the excretions of those organs. The purity of the air depends upon the efficiency with which doors and windows and other ventilating arrangements are made in the class rooms. For each scholar about 200 cubic feet of space, 15 square feet of floor space, and 1500 to 1800 cubic feet of fresh air per hour may be taken as an average requirement. Play-grounds serve the double purpose of allowing space around a school for light and air, and furnishing the necessary means for the children to obtain exercise and pleasure out of doors.

School Hostels.—No description of school hygiene will be complete without some reference to the sanitation in hostels where the students are housed outside the school hours. There are two kinds of hostels or students' messes, generally known as "licensed" and "unlicensed." The licensed ones are under the control of the University or the school or college authorities. The unlicensed ones are without any control whatsoever. No amount of school hygiene will yield any good result unless and until the houses where the students live are also brought under the control of the Sanitary Board. According to the last University Commission Report (1919) during the year 1916-17, as many as 1,896 students were living in unlicensed houses. The hostels should be periodically visited by the medical inspector, and no student should be allowed to live in any unlicensed hostel. In addition to the inspection of general sanitation with regard to water-supply, privies, water-closets, drainage and ventilation, the medical inspector should keep an eye on the

food. This is of vital importance to the health of the present generation of students. Most of the students, are sickly, ill-nourished, and dyspeptic. The same Commission also discusses various causes of the unfavourable conditions of health and physique of the students and attributes them, amongst other causes, to underfeeding, lack of exercise, bad living conditions, and improper diet. The medical inspector should also see that every student acquires a habit of eating at regular hours, and takes enough outdoor exercise.

The building should be constructed on sanitary lines so that each room may have ample provisions for cross ventilation. The room should be big enough to accommodate two boys with a floor space of at least 300 c. ft. per head. It should not be crammed with furniture. One bed, one chair and a table for each scholar are all that is required. A shelf or an almirah may be supplied. The lighting is always faulty where there is no provision for gas or electricity. Hanging lamps are convenient and more desirable than table lamps where the glare of the light affects the eyes. The lights of the corridor, common room, dining hall and all places should be put out after ten at night. In most hostels the lights are kept burning the whole night and no one is held responsible for these details. Wherever possible every hostel should possess a common room and one or two dining halls.

The kitchen should be on a detached portion separated from the main building. The medical officer should see that it is kept clean. The garbage should not be thrown at random but collected in proper receptacles.

The drains, etc., should be properly flushed and kept clean. There must be sufficient number of privies or water-closets and urinals.

Every hostel should have sufficient open space, and wherever possible provided with an open lawn where the scholars can have outdoor games and spend the evening in the open air.

Administration.—The power of medical inspection of schools and attached hostels should be vested in a Board

under the control of the University or the Director of Public Health. All the medical inspectors should be under this Board; where a large number of inspectors are required, as in Calcutta, it is necessary to have one or two supervisors under one director. The director will have to supervise the work of all inspectors and the success will largely depend upon the efficiency and skill of the director. He must have executive ability combined with a thorough knowledge of the subject of medical inspection, and be a good disciplinarian capable of directing wisely.

The director should outline a practical system of inspection, which must be simple and not burdened with clerical work. He should see that there is uniformity in work, and visit the schools and the hostels occasionally to watch the character of the work performed.

The chief difficulties to be considered are administrative rather than educational or scientific, and the feelings and prejudices of the parents have to be taken into consideration. A new element has to be introduced into the school life with the least possible disturbance and inconvenience. In the case of school hygiene, two departments of public administration will have to be brought for the first time into organic connection, those of public health and of public education.

CHAPTER XXII

MATERNITY AND CHILD-WELFARE

THE importance of the question of child-welfare will be evident from the infantile mortality rate for Calcutta, viz.—280·5 in 1918; 357·8 in 1919; 386·0 in 1920; and 330·0 in 1921.

These figures show the high rate of infantile mortality which prevails in Calcutta, not to mention the rural areas, where the conditions are still worse. This heavy mortality is due to several causes, amongst these may be mentioned ignorance on the part of the mother, improper feeding, exposure to insanitary surroundings, adherence to outworn prejudices connected with parturition, quack midwives, immaturity of mothers, etc. In Calcutta about 36.5 per cent. of the total infantile mortality occurs during the first week of life, and is due to ignorance on the part of the mother, neglect, premature birth, debility, and tetanus neonatorum.

As a result of this a movement was initiated by the Corporation of Calcutta to provide trained midwives to attend to confinements amongst the poor, and women health visitors to give necessary advice to prospective mothers with regard to the sanitation of pregnancy, and proper methods of rearing children. Although this movement has been initiated in Calcutta the whole rural population remains as much neglected as ever, where the conditions are no better than they were half a century ago.

The movement for preserving the life of the infant and the child involves other important factors, and the

desirability of keeping an eye on the health of the prospective mother, and of bringing to full term and safe delivery the large numbers of miscarriages and stillbirths, and of providing trained midwives in confinements for the mothers, are all important issues in the preservation of the national life and vigour.

The solution of the problem of maternity and child-welfare is to be found in the circumstances surrounding the life of women of the poorer classes, especially in the rural areas, who are fighting daily against destitution and want. There can be no question that want of elementary ideas in domestic hygiene and poverty are the chief causes at work. Poverty necessitating bad housing, poor and often ignorant feeding and clothing, and insanitation.

Any scheme of maternity and child-welfare must embrace the following, *viz* :—

(1) The protection of motherhood.

(2) The protection of infancy.

(3) The protection of childhood.

The protection of Motherhood.—The question of protection of the mother becomes more important when we realise how the health of the women is being undermined by early and repeated child-bearing, prolonged nursing, insanitary and unhygienic surroundings, bad living conditions, overwork and chronic malaria. About 25,000 to 30,000 mothers in Bengal die every year from causes connected with child-bearing. The protection of the mother, therefore, is an important item in any scheme, as upon the health of the mother depends the health and vitality of the child. This protection should be given during ante-natal, natal and post-natal periods.

Statistics show that death-rates among women are heavily in excess between the ages of 15 and 40, the main child-bearing period. In 1921 alone maternal causes must have been responsible for over 60,000 deaths in Bengal. From the comparative study of the figures of several years it is evident that from 60,000 to 75,000 deaths among women are occasioned by ante-natal, natal and post-natal conditions.

(*a*) *Ante-natal Period.*—Sufficient information is already available to show how an element in the problem of child-welfare is the period when the child is wholly dependent for its continued existence on the health and well-being of the mother. In view of the enormous proportion of infant deaths occurring during the first week or the first month of life, we have to consider the causes to which these deaths are ascribed. This leads us directly to the period antecedent to its birth. Stillbirths, death from immaturity very inadequately represent the total volume of life lost during ante-natal states. Miscarriage is in many instances a perverted habit, beginning more probably in disease or injury, but repeating itself in recurring pregnancies. Other phases of ante-natal problems which require careful enquiry are the occupation of mother, pregnancy occurring too early in life, effect on mother and child of rapidly following pregnancies, influence of syphilis, etc.

The problem of child life is only one part of the subject of ante-natal care. Puerperal sepsis, eclampsia, abortions, anaemia and other forms of illness during pregnancy, if treated in time, or if the conditions under which they arise were in view from their onset, could be greatly alleviated. It may be asserted that if all women were under skilled medical observation during pregnancy about half the ante-natal deaths that now take place could be prevented, and the number of premature births could be reduced. Similarly such conditions as atrophy, debility and marasmus are due to ante-natal conditions which might have been controlled or remedied by ante-natal medical attention. Therefore any scheme to be successful should consist of ante-natal clinics held weekly or fortnightly at a recognised place, and house-visiting of pregnant women by women health visitors. It is possible by proper ante-natal care not only to reduce the death roll of unborn infants, and preserve the life of many infants born to die within a week of birth ; but above all it would be possible to preserve the health of the mothers, to save them from prolonged and exhausting labour, and to restore them after confinement to such condition of health as will

enable them to perform the duties of motherhood in the best possible way.

The whole position of maternity both pre-natal and post-natal demands serious attention from the State, and this not only in its own interest and the interests of the country, but also in the interests of the mothers themselves, most of whom are stricken with poverty, and who should be assured of all the medical skill and nursing facility that are available to their more fortunate sisters in the higher grades of life.

(*b*) *Natal Period.*—In this country care of women during parturition is very much neglected; an unused, dark, ill-ventilated and damp room commonly used as a lumber room, or for keeping domestic animals, like cows, is usually selected as the lying-in room. In the majority of cases, the work is done by quack midwives who are absolutely ignorant of even the very rudiments of hygiene and cleanliness. As a result of all these one of the commonest causes of death in infants during the first week is tetanus neonatorum, and in mothers puerperal sepsis. Those infants who survive the first week die of bronchitis and broncho-pneumonia. During this period such assistance as may be required should be arranged to ensure the mother having skilled and prompt attendance during confinement at house. This part of the work should be done by trained midwives, the health visitors coming to their aid in cases of difficult labour, or any other condition involving danger to the mother or infant.

(*c*) *Post-natal Period.*—This period is very important, for upon the attention paid during this period depends the health of both the mother and the child. Excluding ante-natal conditions, and those arising from the act of birth, the health and development of the child, depend upon its environment. Under this are included those factors which directly or indirectly influence and modify physical, mental and moral growth. These factors are hygienic, *i.e.*, all that pertains to air, washing, clothing, housing, etc., and dietetic. Early commencement of household or other work, want of proper food and clothing are responsible for most of the ill-health of the mother. During

this period treatment of complications arising after parturition, whether in the mother or in the child, should be undertaken by the health visitors. Mothers should be instructed on the proper methods of nursing babies, and on the prevention and care of minor ailments of infants. Most of the ailments of infants are due to improper feeding. In breast-fed infants the cause of the mischief must be sought in the mother; in hand-fed babies the quality, quantity, or mode of preparation of the food, or the condition of the bottles, may be at fault, and all these require careful investigation. The dangers of artificial feeding are especially great during the first few weeks of infant life. After three months the child's digestion acquires a certain degree of stability. It is difficult to assign the mortality to its true cause always, but there is no doubt that improper feeding is the prime cause in a large proportion of the deaths—from intestinal disorders, spasmophilia, rickets, etc.

Maternity and Child-welfare Scheme

The Child-welfare Centre.—The establishment of a centre or centres is the first step, but it must be clearly understood that mere establishment of a centre is not the beginning or the end of the whole scheme. It is only the head-quarters from which different parts of the scheme will radiate.

The centre should consist of a medical officer who may be consulted by the mother. It should consist of a hall where mothers can congregate with their children. There should be arrangements for weighing and measuring babies, and the hall may be utilized for lectures to mothers, demonstrations, and mothers' meetings. The walls should be decorated with appropriate and instructive diagrams and charts. The chief provision, in the centre, besides the medical officer of health, will be qualified women health visitors and some trained midwives. The medical officer of health must be selected from those who have devoted some special study to infant hygiene.

The general work in the centre should consist of—

(*a*) The examination of all babies, and where necessary their mothers by the medical officer on their first visit.

(*b*) To issue printed leaflets in different vernaculars giving instructions with regard to the hygiene of pregnancy, infant care, preparation of infant food, etc., as also instructions with regard to clothing, exercise and rest, care of breasts, etc.

(*c*) To weigh all children, by the nurse especially trained in child-welfare work.

(*d*) To adopt such measures as will popularise the scheme and educate the public, and to organise popular purdah lectures on maternity and child-welfare, illustrated with lantern slides in villages where mothers and expectant mothers are induced to attend.

(*e*) To hold annual baby shows, and prizes offered for healthy and well-kept babies.

(*f*) To make provision for cheap meals for poor expectant and nursing mothers.

(*g*) To arrange for hospital accommodation for expectant mothers shortly before and during labour.

(*h*) To supply good cow's milk, and other articles of infant food free. or at cost price to needy mothers.

(*i*) To supply trained nurses for confinement free to the poor, and for a small fee for others requiring help.

(*j*) To introduce elementary hygiene with special reference to child-welfare in all girls' schools.

The medical officer should generally supervise and co-ordinate the whole scheme.

The Health Visitor or Visitors.—An adequate number of health visitors is the essential factor in any scheme of maternity and child-welfare. A tactful and sympathetic health visitor can accomplish a great deal of useful work by giving advice to pregnant women in their own houses. They should be qualified medical women, and one whole-time health visitor for every 500 births is the usual average number required for the work. The health visitor should treat minor complaints of infants, and should give directions on general hygiene, preparations of infants' and invalids' food, and explain the dangers of bad ventilation

and over-crowding, advise mothers on the management of common ailments of infants and children, and impress upon them the value of breast-feeding. They should help the midwives in cases of difficult labour, supervise their work, and pay periodical visits to the house of infants until they are one year old.

Provision for an Efficient Midwifery Service.—For those who cannot afford to engage the services of a trained midwife the centre should provide the services of a competent midwife gratuitously. Arrangements, therefore, should be made for an adequate supply of trained midwives in each area. In places where competent midwives are not available the centre should make provision for the maintenance of at least one in such places. These midwives should undertake confinement cases either on a small fee or gratuitously as the case may be. Not only in villages, but also in cities like Calcutta, too much of the midwifery is done by quack midwives. These women are a hinderance to any scheme ; they are not competent to give proper advice to pregnant women, and during confinement they practically court infection by having absolutely no idea of the elementary principles of cleanliness, sepsis and asepsis, and do a good deal of harm both to the mother and the infant. Since it is not possible to replace the quack midwives for some time to come, it would serve more useful purpose if these women could be trained in midwifery and child-welfare work. They should also be induced to attend the lectures at the different centres, or such lectures organised for their benefit locally. Proper provision for safe midwifery is essential, and it should be the duty of every one concerned in the child-welfare scheme to urge on expectant mothers the necessity of a properly-trained midwife ; and the workers should be in a position to supply such help.

It may be mentioned here that the mere establishment of child-welfare centres will not yield any fruitful results unless the workers, with whom the success of the whole scheme depends, are willing, conscientious and smypathetic. The health visitors and the midwives can help a good

deal to popularise the scheme by their kindly manners, genial personality, and readiness to help those requiring help. All this is the work of local organization, but there is a phase of the question which requires direct State help, not simply of a financial character.

The Maternity and Child-welfare Act of Great Britain empowers all the local authorities to make arrangements for attending to the health of prospective and nursing mothers and of children under five years. They are entitled to provide *crèches* and day nurseries, to establish convalescent homes, for nursing mothers and children under five years, to provide home-help and other assistance for securing proper conditions for the confinement of necessitous mothers, to provide maternity and child-welfare centres with midwives and maternity nurses.

One of the ideal centres in England consists of a wholetime doctor, four health visitors, a dental clinic, a hospital for most difficult cases of confinement, a centre to which pregnant women can go for advice, and a centre from which food and milk can be distributed under certificate of medical officer of health to women who are necessitous, or who cannot obtain proper food and milk for their condition. The centre possesses a maternity home with sixteen beds and, if used a fortnight by each mother, will provide for 240 women a year.

The duties of medical officers of child welfare centre may be summarised as follows :—

A. Clinical Duties :—

1. Prenatal Clinic :
   (*a*) *Normal Cases.*—Advice on hygienic pregnancy and instructions in the case of infants.
   (*b*) *Abnormal Cases.*—These should be referred to
      (i) own family doctor, or
      (ii) special hospital, or
      (iii) treatment section of the clinic.
2. Post-natal Clinic :
   (*a*) Medical consultation of those who desire same up to six weeks after confinement.
   (*b*) After six weeks these consultations to be merged with infant consultation.

3. Baby Clinic :

(*a*) *New-born infants.*—All babies brought to the clinic for the first time should be examined by the medical officer.

(i) *Healthy and normal infants.*—Mothers to be advised on infant care and management.

(ii) *Abnormal infants.*—To be referred for treatment.

(*b*) Other infants should be examined by the medical officer and classed as above.

NOTE.—The primary duty of the clinical officers at welfare centres is the prevention of defects and the education of the parents in the early detection of the same.

If any conditions are found affecting either the mother or the infant, which may be attributed to mismanagement or neglect on the part of the obstetrician, he should be notified of the defects discovered.

B. Administrative Duties :—

1. Procedure to carry out

(*a*) notification of birth,

(*b*) ophthalmia,

(*c*) control of puerperal fever.

2. Organisation of

(*a*) health visiting,

(*b*) supervision of midwives.

3. Co-ordination between

General public health work, maternity and child welfare work and school medical service.

CHAPTER XXIII

VITAL STATISTICS

VITAL statistic is the science of numbers applied to the life history of communities. The general state of the public health in every country depends largely on the measure of adjustment of the relation of the individual and the race to the environment, the more complete and continuous the adjustment the greater the longevity. Of the problems of life with which the science of vital statistics is concerned the following are of special importance, viz. population, births, marriages, sickness, and deaths.

A thorough enumeration of the population as well as the registration of births and deaths according to their causes and at different periods of life form the natural basis of vital statistics. But it is necessary to explain that the vital statistics of India are of a defective character. There is no record of marriages and an inadequate one of sickness. Registration was first introduced in India about fifty years ago, but the difficulties encountered have been great. The people, doubtful of the object, do not like to make their domestic affairs public. The statement of the causes of death leaves much to be desired, as many die without being attended by qualified medical men, and attribute all cases of death accompanied by a rise of temperature to "fever." Moreover, during an epidemic the real cause of the disease is concealed in order to escape sanitary measures.

To improve the registration of births and deaths, that is to bring vital statistics up to a desired standard, the local authorities should insist on having a daily record of all deaths registered at the burial-grounds and burning ghats and compare these with those already reported at

their office for registration. In cases of deaths not reported the authorities should take suitable action against the defaulters as provided by the Acts. In the case of births, measures should be taken to force the householder, or the parents, or to induce the midwives or *dais* to report all births within a fixed period (usually seven days). The vaccinators as well as the outdoor municipal staff should enquire about all such events during their rounds and report to the authorities any cases of omission for proper steps.

In India the first census was taken between 1867 and 1872 and was repeated in 1881 and subsequently at intervals of ten years, and the last was taken in March 1921. The value of these enumerations has been very great, although the return of ages is by no means accurate, since the majority of people being illiterate cannot furnish correct statements of age and occupation. But the figures enable us to make an approximate estimate of the true birth- and death-rates and of the mortality by age and sex and thus afford data for the construction of a life table.

Estimation of Population.—This is generally done by the following methods :—

1. If a strict record of emigration and immigration be kept then in a country in which a complete registration of births and deaths is enforced the population can be ascertained by balancing the *natural increase* by excess of births over deaths and increase or decrease due to migration.

2. The increase of inhabited houses in a district being known the increase of population may be estimated on the assumption that the number of persons per house is the same as in the last census.

3. Another method is by calculating from the average birth-rate of the last ten years. It is worked out by the following formula—

$$P = \frac{\text{Registered births in the year} \times 1000}{\text{average birth-rate for the last ten years.}}$$

Thus, if the birth-rate of a town for the ten years (1910-

1919) was 30 per 1000, and the actual number registered in 1920 was 450 ; then the population for 1920 will be according to the formula $\frac{450 \times 1000}{30} = 15{,}000$

Therefore the estimated population for 1920 is 15,000.

4. This method assumes that the rate of increase is constant, and is the same as existed during the previous intercensal period of ten years.

Thus, if P=population of any census year,
R=annual increase,

Then one person becomes $(1+R)$ at the end of 1 year ; and P persons become $P(1+R)$. At the end of the second year $P(1+R)$ persons become $P(1+R)\times(1+R) = P(1+R)^2$,
at the end of 10 years they become $P(1+R)^9 \times (1+R) = P(1+R)^{10}$. At the end of n years become $P(1+R)^n$.

If P′=population required
then $P' = P(1+R)^n$

By using this formula the rate of increase during any intercensal period of ten years can be found by replacing n by 10.

For practical puposes the logs of each side are taken, thus,

$$\begin{aligned}
\log P' &= \log P(1+R)^n \\
&= \log P + \log(1+R)^n \\
&= \log P + n\log(1+R)
\end{aligned}$$

$$\text{therefore } n\log(1+R) = \log P' - \log P$$

$$\text{or } \log(1+R) = \frac{\log P' - \log P}{n}$$

$$= \frac{\log P' - \log P}{10}$$

The following rules are used in estimating the population, viz.—

1. $\log P' - \log P$ = log rate of 10 years increase.
2. $\frac{\log P' - \log P}{10}$ = log of annual increase.
3. $\frac{\log P' - \log P}{10 \times 4}$ = log rate of quarterly increase.

N.B.—Instead of 4, it may be multiplied by any number and the product=log of the increase of those years.

Example :

If the census population of a town is 32,000 in 1901, and 36,000 in 1911.

Then log P′—log P or log 36000—log 32000=log of ten years increase, *i.e.* 4.5563025—4.5051500=0.0511525 or log 1.125 ten years increase.

On dividing the difference by 10 we get 0.0051152= log annual increase.

Birth-rate.—An accurate registration of births is as nécessary to the sanitary statist as an accurate knowledge of population obtained from the census. Statistics based on the birth-rate calculated on the total population, are of value in considering the progress or decline of a community in a series of years. Strictly speaking, they are not a correct record of the fecundity of the people as they depend not only on the number of births and adults producing offspring, but also in the number of young and old persons, who contribute nothing in the increase of the population. Births are usually reckoned at a rate per 1000 of population. The *annual* birth-rate of a community is calculated according to the following formula :—

$$\frac{\text{number of births in one year} \times 1000}{\text{the population}}.$$

Example :

There were 250 births in a year out of a population of 10,000 ; find the annual birth-rate for the year.

According to the formula we have $\frac{250 \times 1000}{10,000} = 25$ births per 1000.

The birth- and death-rates may be calculated from weekly, monthly, or quarterly returns. A *weekly* birth-rate is calculated as follows :—

$$\frac{\text{number of births during one week} \times 52.17 \times 1000}{\text{the population}}.$$

A *monthly* birth-rate=

$$\frac{\text{No. of births recorded in 4 weeks} \times 13 \times 1000}{\text{the population}}.$$

A *quarterly* birth-rate =

$$\frac{\text{No. of births recorded in a quarter} \times 4 \times 1000}{\text{the population}}.$$

Causes affecting Birth-rates :

1. *Marriage Custom.*—This undoubtedly plays an important part in India as marriage is a religious obligation with the Indians. Here polygamy is permitted, widowers may remarry, but not the widows as a rule. Marriage usually takes place at an early age and there is a disparity in the ages of husband and wife ; and, as a consequence, an excessive proportion of widows.

Among the Mahommedans, Buddhists, and Brahmos the age of females at marriage is generally higher and the disparity in the ages of husband and wife is less : there is also less restriction on widow remarriage.

2. *Agricultural Distress or Prosperity.*—The birth-rate is a sensitive barometer of prosperity ; with a marked rise or fall in food prices there is a similar movement in the death-rate and an opposite movement in the birth-rate nine months later.

3. *Normal Seasonal Variations.*—Seasonal variations have an influence on the birth-rate. On irrigated tracts with adequate drainage and abundant crops the birth-rate is high ; in water-logged areas where the soil deteriorates and the people are prostrated by chronic malarial disease there is depopulation from impairment of fecundity.

A more scientific method of stating the birth-rate, than that of the reckoning to annual births to 1000 of the population, will be to calculate the proportion of births to every 1000 women of conceptive age, *i.e.*, between the ages of 15 to 45 years. This methods is called the "corrected birth-rate."

Still births are not counted either as births or deaths, but are recorded separately.

Death-rate.—Death-rates are calculated in the same way as the birth-rates :—

The annual death-rate =

$$\frac{\text{number of deaths in one year} \times 1000}{\text{the population}}.$$

Although the registration of deaths in India is defective the recorded rates are generally very high and exhibit a progressive rise. The average death-rate for the whole of India for the year 1921 was about 30 per mille. The rates for different provinces taken separately, varied between 20 per mille for Upper Burmah and Madras, to 46 and 44 per mille for United Provinces and Central Provinces respectively. Whereas the total death-rate in Great-Britain in 1911-15 was 13·8 per mille.

This enhanced death-rate is due to the fact that India suffers more than Europe from epidemic diseases which have practically disappeared from where sanitary methods have reached a certain level of effectiveness. The general death-rate of a population is taken as the test of the sanitary condition of the place.

In large towns a certain number of deaths occur in institutions like hospitals, jails, etc., and these should be allowed to the districts in which the deceased persons resided previously.

The sensitiveness of Indian death-rates to sanitary conditions is remarkable, and their fluctuations are greater than those of European populations. This sensitiveness may be attributed to several causes, viz. :—

1. The low age-constitution of the population, which naturally favours a low death-rate.

2. The high birth-rate, infantile mortality forming a large proportion of general mortality and being notoriously sensitive to sanitary conditions.

3. The early marriage of all girls, which causes the population to breed up to its means of subsistence, and renders it easily and extensively affected by want.

4. The high death-rate, which is more easily and largely affected by favourable conditions than a low death-rate, and conduces to a low mean age of population.

In addition to the different epidemic diseases India not only suffers from some of the most serious diseases of temperate climates, but has a long list of infectious diseases special to the tropics.

In order to obtain a perfect idea of the death-rate in a given population or community the total number of deaths

in each sex in proportion to the number of the living should be stated. In regard to sex, while the estimated death-rates during 1911-1920 at all ages in Bengal are 31·7 and 30·5 per mille for males and females respectively, there is a notable contrast in the relative incidence of mortality on the 10-34 age-periods and the rest of life. The female death-rate amongst children under one year is lower than the male, but this gradually diminishes until the age of 6 or 7 is reached. From this age the female death-rate begins to increase– the highest being reached at 15 to 20, after which the difference diminishes until at 35 it disappears and thereafter the female rate remains lower. It appears, therefore, that the highest number of deaths among females occurs during the child-bearing period, *i.e.* 15 to 40 years (*See* table page **548**).

The following table gives the average number of female births and deaths per 1000 male births and deaths for two decades :—

Province	Births		Deaths	
	1911	1921	1911	1921
Bengal ..	941	933	895	909
Bihar & Orissa .	955	950	940	936
Bombay	926	925	936	957
Burma .	938	945	849	901
Central Provinces .	954	955	917	923
Madras	958	956	961	979
Punjab	909	906	983	928
United Provinces .. .	924	919	957	918

Death-rates obtained from mortality returns of short periods, *e.g.*, a week or a month, are not to be depended on as tests for health, as they are liable to accidental fluctuations. The same is also the case with death-rates of very small populations even if returns for a year be made.

Combined death-rate means the total death-rate of a combination of two or more districts, and is estimated from the ratio which the two or more populations bear to one another.

To find out the death-rate of a combined district where the death-rates of the individual districts are known, the following calculations are made, viz.—

Let A = population of one district

x = its death-rate per 1000

then $\frac{x \times A}{1000}$ = total deaths in A.

Let B = population of another district

y = its death-rate per 1000

then $\frac{y \times B}{1000}$ = total deaths in B.

Therefore $\frac{x \times A}{1000} + \frac{y \times B}{1000} = \frac{Ax+By}{1000}$ = total deaths in combined district A and B.

and $\frac{Ax+By}{1000\ (A+B)}$ = death-rate per unit in A+B.

and $\frac{Ax+B}{A+B}$ = death-rate per 1000 in A+B.

Thus if A has a population of 5000, B of 10,000 with a death-rate of 20 and 15 per 1000 respectively, then the death-rate of the combined districts with a total population of 15,000 would be as follows :—

$$\frac{Ax+By}{A+B} \text{ becomes } \frac{5000 \times 20 + 10000 \times 15}{5000+10000} = 16.6 \text{ per } 1000.$$

Corrected Death-rates.—It is well known that the death-rate under five and over fifty-five years of age is higher than the combined rate for all ages, whilst between five and fifty-five it is lower. Hence the death-rate will be raised in a town having an undue proportion of infants, and old people. Again, at nearly every age-group the death-rate of females is lower than that of males ; hence an excess of females in a population or town will lower the death-rate. It is therefore necessary that some correction must be made in a death-rate of a town or district for any such disproportionate distribution of age and sex, before its rate is comparable with

that of another town or district. The method for making this correction is as follows :

Age period	Population divided for age and sex (1901 Census)		Death-rate (E. and W.) (1891-1900)		Calculated number of deaths.	
	Male.	Female.	Male.	Female	Male.	Female.
0-5	562	571	62 7	52.8	35.23	30.16
5-10	534	547	4.3	4 4	2 29	2.40
10-15	513	520	2 4	2.6	1 23	1.35
15-20	496	505	3 8	3 7	1 88	1.97
20-25	etc.	etc.	etc.	etc.	etc.	etc
25-35						
35-45						
45-55						
55-65						
65-75						
75-85						
85 and upwards						
	4873	5127			83	91
Totals	10,000				174	

Now take the case of a town with a population of 10,000 at the census of say 1901. Distribute the population according to age and sex into the twelve age-groups (as in the table above) as per figures obtained from the census returns, and apply to the population of each age-group and each sex the death-rate for that particular age and sex obtained for England and Wales generally during the last intercensal period of ten years, and calculate the number of deaths which each such rate produces, thus :

Take the males at ages 0-5, *viz.*, 562. The death-rate for England and Wales for males at that age period being

62.7 per 1000, the total number of deaths amongst the population of 562 will be $\frac{562 \times 62.7}{1000} = 35.23$. Again in the next age-group, *i.e.* between 5-10 years with a death-rate of 4.3 per 1000 means $\frac{4.3 \times 534}{1000} = 2.3$ deaths among 534 males of that age-group. Calculating in the same way for each age-group and each sex it will be found that the total deaths will come up to 174, that is to say there would have occurred 174 deaths or $\frac{174 \times 1000}{10000} = 17.40$ per 1000 among a population of 10,000 persons at the same rate as obtained in England and Wales generally. This rate of 17.40 per 1000 is known as the *standard death-rate.*

The Standard Death-rate is merely a hypothetical one and is calculated on the assumption that the deaths in a town or district occur at the same rate as in England and Wales generally.

Having applied the England and Wales death-rate at each group to the population of the town or district the *standard death-rate* for the place thus obtained ought to be the same as in England and Wales, other things being equal. But this is not actually the case as the rate of mortality for England and Wales during the ten years of 1891-1900 was 18.2 per 1000 ; hence the age and sex distribution of the town or district are obviously different from that of England and Wales. The *standard death-rate* must therefore be raised in the following proportion to make it comparable with that of England and Wales.

$$\frac{\text{rate for England and Wales}}{\text{standard death-rate}} = \frac{18.2}{17.4} = 1.045.$$

The factor for correction for that particular town or district, then, is 1.045. Now if the general (*i.e.* the recorded or crude) death-rate for any year be multiplied by this factor, *the corrected death-rate* is obtained. Therefore Corrected D. R. = General D. R × Factor. Suppose,

for example, the crude death-rate of a town for 1910 was 16.5, then the corrected death-rate for that year would be $16.5 \times 1.045 = 17.24$.

It is generally found that the age and sex distribution, expressed as a ratio to the total population remains fairly constant—except in big and important industrial towns—during an intercensal period. It is for this reason the factor is calculated once in every ten years—the last factor holds good until a fresh factor is calculated from new figures obtained from the next census.

Comparative Mortality Figure.—This is a useful means of expressing a comparison of the death-rates of different towns or districts. For any year it is

$$\frac{\text{the corrected death rate} \times 1000}{\text{death-rate of E. and W. for that particular year.}}$$

For instance the death-rate for England and Wales for 1905 was 15.2 and the corrected death-rate for a town was 17.24, therefore

$$\text{the C. M. F.} = \frac{17.24 \times 1000}{15.2} = 1{,}134.$$

This number "1134," is the *comparative mortality figure* and is the corrected death-rate for the town compared with the death-rate of England and Wales, taken as 1000. It means the number of persons which in 1905 produced 1000 deaths in England and Wales produced 1134 deaths in the particular town after correction for differences in age and sex distribution.

It may be noted here that the statistical figures are never so accurately and studiously worked out in India as in England and Wales.

Relation between Birth-rate and Death-rate.—It is generally held that a high birth-rate is a direct cause of a high death-rate owing to the great mortality among infants. The death-rate at ages under 5 is three times as high as of all ages together, and a high birth-rate by producing an excessive proportion of persons of tender years will cause a high general death-rate. But the mortality falls if the high birth-rate were to continue longer, for then the proportion of the total population at ages

of low mortality would be increased and the general death-rate lowered.

The following table gives the death-rate per mille at different age periods amongst males and females in Bengal.

Age.	Average of Period 1918-1920.		Average of Decade. 1911-20.	
	Males	Females	Males	Females.
0-5	135	128	125	116
5-10	20	17	17	14
10-15	16	15	12	11
15-20	23	25	17	19
20-40	27	29	20	22
40-60	42	36	35	32
60 and over	88	72	81	67

Infant Mortality.—Good deal of attention is being given of late to the study of infant or child mortality. The infantile death-rate is usually calculated as so many deaths under 1 year of age per 1000 registered births in the year.

Infantile mortality has been steadily falling in most countries since 1881. The decline between the period 1881-1885, and 1900-10, being 25.6 p.c. in France, 15.8 p.c. in England, 23.7 p.c. in Switzerland. Studies of the statistics show that there is a close correlation between the infant mortality rate and the size of the family, owing to two distinct set of factors, viz., physical and economic. On the one hand the vitality of the mother, and through her the life of the child appear to be affected, by the age at which the child bearing begins, the number of pregnancies and the spacing of births, on the other hand the health of the infant is intimately associated with the circumstances frequently associated with large

families, viz., poverty, congestion, malnutrition, insanitary surroundings and the ignorance of the parents.

Other things being equal it gives an index of the sanitary condition of the place as well as of the density of the population. One noticeable feature of the statistics of infantile mortality is that it is higher among male than among female children. It is a known fact that male infants are more delicate and more difficult to rear than female infants.

The heavy mortality amongst infants is partly ascribed to immaturity and ignorance of the mother, to improper feeding, to exposure of infants to all insanitary surroundings wherein the cause of malaria, small-pox, measles, bowel complaints, and tetanus abound. Although a large proportion of deaths is due to premature birth and debility, there is no doubt that many are also due to ignorance and neglect, for the death-rate among infants of the poorer classes attended by the Corporation midwife is only 55 per 1000 during the first seven days. (*See* "Maternity and Child-welfare").

The infant death-rate for the whole of India amounts to about one-fifth of the total death-rate of all ages, and about one-fifth of the children die before the age of one year.

Infantile mortality rate or I. M. R. is calculated as follows :—

$$\text{I. M. R.} = \frac{\text{Death under 1 year} \times 1000}{\text{Registered births.}}$$

If there were 600 births registered during the year, and 75 deaths among the infants under 1 year, then the infantile mortality rate should be 75 deaths per 600 births or $\frac{75}{600}$ deaths per birth or $\frac{75 \times 1000}{600} = 125$ deaths per 1000 births, *i.e.* I. M. R.$=$125.

Density of Population.—The density is usually expressed as so many persons to a square mile (in rural areas) or an acre (in towns). This has an important bearing on the death-rate and exercises a great influence on the population. The greater the density the higher

the mortality. Farr states that the death-rate increases with the density of populations, not in direct proportion but in proportion to the sixth roots of the contrasted populations. But this rule does not hold good generally. It is only when the density reaches a certain degree that its bad effects are manifest.

Increased density of population usually means pollution of air, water, and soil, and a rapid and easy spread of infectious diseases. There is also greater filth, crime, drunkenness and other excesses. In India increased density in country districts may be beneficial to public health by removal of waste lands and increase of cultivated areas. In towns people enjoy certain advantages as regards prompt removal of refuse and supply of a pure and wholesome drinking water, which are usually denied to those who live in villages. In rural areas the density of population hardly affects the health or mortality. But in towns this has an injurious effect on health.

Though somewhat smaller than Great Britain, Bengal has more inhabitants than the British Isles. The three most densely populated provinces in British India, according to the census of 1921 are Bengal with 579, the United Provinces of Agra and Oudh with 414 and Bihar and Orissa with 340 persons to the square mile.

Occupation and Mortality.—Occupation exerts a certain amount of influence on the health and mortality of the people. In order to make correct statistics showing the influence of occupation on mortality, the number and the age of those engaged in each calling and the corresponding number of deaths should first be ascertained, and the mortality is calculated from the deaths taking place in each particular occupation. This has been very successfully worked out in England but not in India. Roughly speaking the mortality is comparatively high among workers in cotton, jute, or paper mills, or in the manufacture of mineral acids, poisonous metals, etc., or among those whose occupations necessitate constant exposure to sun and rain and to changes of weather. Sedentary occupations have a deteriorating influence on health.

Some occupations require strong and healthy persons and due allowance must therefore be made for the age at which such occupations are followed. For purposes of comparison the death-rates among those employed at corresponding age periods must be taken.

Special Death-Rates.—It is important to know the rate of death from different causes. It has been stated that "the causes of death in a death register are necessarily little more than the more or less trustworthy guesses of a large body of more or less skilled observers." If this statement applies to England, where certificates of death are required, one can well imagine how things stand in India where the majority of people die without proper or rational treatment, and where no such certificates are insisted upon.

In India for statistical purposes deaths are classified under the following heads :

1. Cholera.
2. Small-pox.
3. Plague.
4. Fevers.
5. Dysentery and diarrhœa.
6. Respiratory diseases.
7. Injuries { Suicide. Wounds and accidents. Snakes and wild beasts.
8. All other causes.

The following table shows the actual number of deaths from different diseases and the average annual rate per mille of each sex in Bengal :—

Disease.	1919.		1920.		Ratio per 1000 1920.	
	Males.	Females.	Males.	Females.	Males	Females.
Cholera	67,601	57,348	29,762	24,437	1 3	1.1
Fever .. .	639,036	590,221	593,523	550,898	25.5	25.0
Small-Pox	20,468	16,542	20,013	16.177	0 9	0.7
Plague	288	136	46	20	0·002	0.0009

It is important that the causes of death should be entered according to the official nomenclature, and to

state the remote rather than the proximate cause. Thus death from diarrhœa or dysentery in case of kala-azar should be returned as death from kala-azar.

The registration of sickness for the general population is not feasible although it has been effected in certain companies, societies, and institutions like jails, etc. According to Dr. Farr's estimate, two persons are constantly sick for every annual death which occurs, *i.e.* for one death there are two years of severe sickness. The sanitary officer would be in a better position to deal with preventable diseases, if information of the occurrence of every case, whether fatal or not, were supplied to him, and he could then inquire into the causation of all such cases. It is as important that a correct estimate of the number of persons invalided by sickness should be kept as well as the actual number of deaths.

Probable Duration of Life (*vie probable*) is the age at which any given number of children born alive will be reduced to one half. This can only be ascertained from a life table.

Life Table.—A life table is a true *biometer*, because it represents "a generation of individuals passing through life to extinction." The data necessary for its construction are the number, age, and sex of the living and the mortality figures of one or more years for the same population classified according to age. Theoretically the ideal plan for forming a life table will be to observe a million live-births, all born on the same day, through life, entering in a column (headed l_x) the number surviving at the end of each succeeding year until all have died ; and in a second column (headed d_x) the number dying before the completion of each year of life. This is absolutely impossible to carry out in practice. The only practicable method adopted for making life tables is to assume that, the population being given by the census returns, and the mortality for each age for a given decennium being known, the same mortality will continue during the rest of the life of the population included in the census returns.

The total mean number living and the total number dying for a given age period are known, the mean chance

(p_x) of living one year during this age period is found as follows :—

$$\frac{\text{Population}-\frac{1}{2}\text{ deaths}}{\text{population}+\frac{1}{2}\text{ deaths}}=p_x$$

It is usual to start with a million or 100,000 children at birth, and to make a separate table for the proportionate number of males and females at birth. Starting with a certain number of babies (l) at birth, if l is multiplied by the probability of living one year the number surviving at the end of the year is obtained. Similarly the number living at the end of the second year is obtained by multiplying the number commencing the year by the probability of their surviving the year, and so forth.

From what has been said above it will be seen that if the necessary data can be had life tables for individual towns, districts, or countries can be prepared. A life table gives a scientific basis on which calculations for life assurance are based.

The *expectation of life* at any age is calculated from the number surviving at that particular age (as obtained from a life table) and from the years of life they subsequently live, just as in the *mean duration of life* (expectation of life at birth). For the ages between 25 and 75 Willich has devised the following formula, which gives approximate results :—

If x=expectation of life and a=present age, then $x=\frac{2}{3}(80-a)$.

The *mean duration of life* (*vie moyenne* of the French) can be approximately calculated from Dr. Farr's formula. According to this, if b=birth-rate and d=the death-rate per unit of population, then x or expectation of life at birth

$$=\left(\frac{2}{3}\times\frac{3}{d}\right)+\left(\frac{1}{3}\times\frac{1}{b}\right)$$

Another rough rule for estimating the expectation of life is as follows : Between the ages 20 and 45 use the fixed number 96. Subtract the present age of the individual from this number and half the remainder is his expectation of life. Between the ages of 20 and 80 the

result is slightly below the average, while over 40 it is rather high. For calculating the estimation of life over 45 take 90 instead of 96 as the fixed number.

The term *expectation of life* means the average number of years which an individual at a given age lives, and so it implies the chances of living of a mixed community and not that any person may reasonably expect to live a given number of years. The mean age of the living is calculated by dividing the sum of the ages of the population at the census by the number of the population. As a test for longevity it is unreliable, being much disturbed by immigration and insanitation.

The mean age at death (of a population) is the expression of the average age at death of a population and do not give any indication of the health or sanitary condition of the people. It is worked out by adding together the ages at which people die, and dividing the number of years by the number of deaths. It cannot be taken as an index of the healthiness of an occupation.

Age.	Expectation. A	Expectation. B	Age.	Expectation. A	Expectation. B
20	..	33.65	52	12.63	17.38
22	31.43	32.49	54	11.71	16.25
24	29 85	31 41	56	10 72	15.09
26	28 32	30.36	58	9.68	13.91
28	26.84	29 31	60	8.72	12.74
30	25.39	28.26	62	7.93	11.39
32	24 02	27.22	64	7.27	10.54
34	22.72	26.19	66	6.62	9.52
36	21.49	25 16	68	5.92	8.54
38	20 28	24 13	70	5 20	7 62
40	19.07	23.10	72	4.50	6.75
42	17.86	22.12	74	3.80	5.95
44	16.69	21.18	76	3.10	5.23
46	15.57	20.29	78	2.41	4.57
48	14 53	19.39	80	1.72	3.98
50	13.55	18.43			

Colonel Joubert, in comparing the expectancy of the lives of the natives of India with those of Europeans, observes that though the constitutions of healthy Indians may not be much inferior to the European standard from

a medical point of view, their habits, modes of life, and the insanitary conditions amidst which they live are most distinctly inferior to the European standard, and render them more liable to acute diseases increasing the risk of assurance. For Europeans and Eurasians living in India the expectation of life as given in the table on page 549 has been calculated in some details. Table A is based totally on Indian experience from European and Eurasian lives, while Table B on Indian experience from European lives only up to the age of 50.

Marriages.—These are usually stated in proportion to the total population, or the number per 1000 of population; but a more accurate method would be to base the marriage-rate for comparative purposes on the number of unmarried persons living at marriageable ages. With the Hindus marriage is an obligatory religious sacrament and is practically universal. The universality of marriage tends to produce a rapid increase of population. About half the total number of males are unmarried, and of these three-quarters are under 15 years of age. Only one-third of the total number of females are unmarried, and of these three-quarters are under the age of ten and seven-tenths of the remainder under fifteen.

In the following table the proportion of widows in the population per 1000 and for certain age-periods are given and compaied with the figures for England and Wales :—

Age.	India 1921.	England and Wales 1911.
All ages	175.0	73.2
0-5	0.7	..
5-10	4.5	..
10-15	16.8	..
15-20	41.4	
20-25	71.5	1.5
25-35	146.9	13.1
35-45	325.2	50.5
45-65	619.4	193.3
65 and over	834.0	566.9

The great difference between India and England in respect of marriage customs is shown by the fact that in

England from three-fifths to two-thirds of both sexes are single and about a third are married. Three features are peculiar to India, viz. universality of marriage, the early age of marriage, and the large proportion of widows.

There is probably a direct relation between early marriage and the duration of the reproductive functions, and the premature strain of the latter tends to their earlier cessation. Dr. Duncan found the average fecundity of women marrying at 15 to 19 years of age was 9.12, and it progressively diminished as ages advanced, being 4.6 for those marrying at 30 to 34 years.

$$\frac{\text{Births}}{\text{Marriages}} = \text{mean fecundity per marriage.}$$

The rapid succession of the generations, probably five or more in a century, is, however, favourable to the process of adjustment to an environment that is subject to constant changes.

CHAPTER XXIV

VILLAGE SANITATION

THE question of improving the sanitation in villages is a problem which is engaging much attention at the present moment. An efficient sanitary campaign has to be undertaken before any good result can be expected, and this can only be attained by a concerted action by both the public and the sanitary authorities. Most of the villages are not as a rule controlled by municipalities, the District Boards and Union Boards are responsible for the improvement of sanitation and public health of the villages, and in most cases their funds are not sufficient to undertake an elaborate scheme.

For the improvement and development of villages, an Act, known as the Village Self Government Act, 1919, has been passed, which will apply to all parts of Bengal not under the control of a municipality.

The insanitary condition of the villages is responsible for most of the deaths from preventable diseases, chiefly malaria and the water-borne ones. This is due mainly to the ignorance of the people on the elementary principles of hygiene, and to their bad and insanitary habits which have become almost a part of their nature, and to the general apathy of the educated and the well-to-do people to take an initiative, and who very often migrate to town and other healthy places. As a result of all these the villages are left in a very neglected condition, and the poor are left to take care of themselves. One must realise that without co-operation of the people efforts of sanitarians to improve the sanitary condition of villages must perforce be inoperative. Any scheme, however

modest, for the improvement of sanitation in villages, must primarily aim at

1. educating the public,
2. providing good water-supply,
3. proper conservancy, and
4. protection against malaria, hook-worm, and other water-borne diseases.

1. **Educating the Public.**—This is of primary importance inasmuch as upon this the efficiency of any sanitary measure depends. No matter how perfect the measures might be, if the people are not educated enough to appreciate the advantages of such measures these are most likely to fail. The people can be educated by

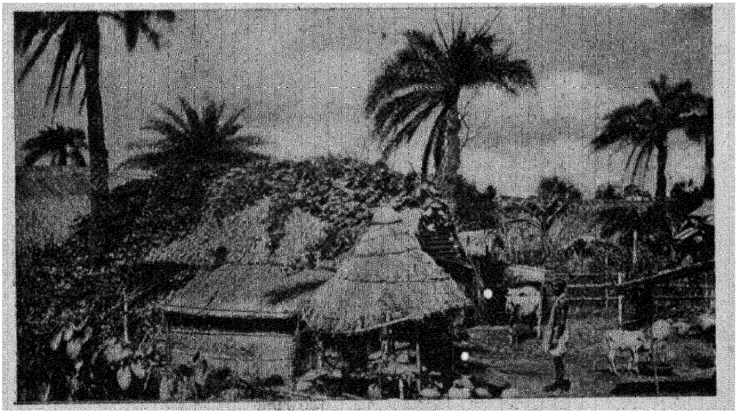

FIG. 93.—AN INDIAN VILLAGE.

organising popular lectures, preferably illustrated by lantern slides and pointing out to them the dangers of insanitary habits. They should be told of the dangers of overcrowding, of dust and disease, of measures necessary to prevent infantile mortality. Easy means of avoiding preventable diseases can very well be illustrated, and the effects of bad ventilation, insanitary surroundings and pollution of water should be impressed on them forcibly.

In villages most huts have mud walls without any openings for ventilation save and except the door. Cattle and other domestic animals are kept in the same room where food is generally stored or perhaps cooked. In the construction of these huts the earth is dug out from the neighbouring land which forms a hollow and eventually becomes filled with dirty water, and forms a breeding place for mosquitoes, and not infrequently this water is utilized for washing and other domestic purposes. People should be taught to build sanitary huts, and model bustees should be built to set an example (*See* page 120).

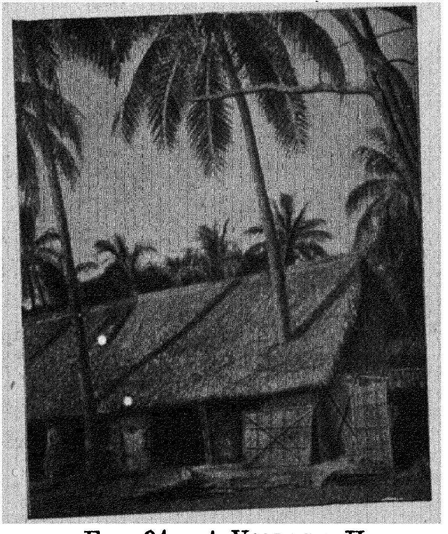

FIG. 94.—A VILLAGE HUT.

2. **Water-Supply.**—This is another great problem for villages where there is no public water-supply and consequently the water for drinking and cooking purposes is drawn from any source available, such as rivers, tanks, wells, etc., which are usually very highly contaminated being used for every purpose. Wells are constructed

without any regard to the sanitary laws, and are sunk too close to privies or drains, and the interior not made water-tight by cement coating, with the result that offensive matter gains admission into the water and makes it foul. Trees grow at their edge, plants sprout from the lining, and dead leaves fall and rot in the water. Birds build nests in the crevices, and fish and turtles are frequently put into the well to keep the water clean. Every user of the well brings his own vessel and rope for drawing water and the rope in the intervals may tether a cow or lie in some dirty corner.

Tanks are more liable to contamination than wells owing to the fact that these are less protected, and both

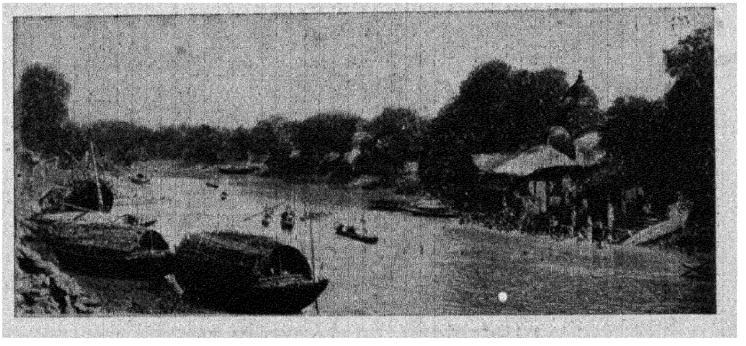

FIG. 95.—A SMALL STREAM IN A VILLAGE.

men and animals get access direct into the water. Unfortunately in non-municipal areas very little attention is paid for protecting the tanks from contamination. Ways in which tanks are polluted are innumerable : people will wash their mouth, bathe, pass urine and stool on the banks, wash clothes, cooking and other utensils, and bathe domestic animals. Privies are often constructed close to these tanks. The result of all these insanitary habits is obvious, and the public should be clearly explained of the dangers of such practice. Some arrangement must be made for good water-supply, and one or two ideal

tanks should be dug and kept under proper supervision to be used only for drinking purposes. Rivers and streams are also open to contamination of all sorts in the same way as the tanks, and generally become the public latrine on account of the customary ablution, and thus the germs of cholera and typhoid fever are carried and spread among the people, and it is therefore neither safe nor desirable to drink water from any such sources unless they are purified by boiling. The public therefore should be taught of the supreme importance of having pure water for drinking purposes and of avoiding drinking water from any sources not properly protected against pollution.

The question of providing a supply of pure water in rural areas is therefore most important. It is neither very difficult nor, is it necessarily, a very expensive matter to provide pure water. Tanks or wells if properly constructed and looked after should afford supplies of good water at a relatively small cost. Where funds permit, tube wells may be used. These are very convenient, and since there is less chance of contamination they are well suited for the purpose. The water of large tanks when properly reserved is often so pure as to require no filtration. Ordinary wells constructed with due regard to their surroundings and properly looked after would also afford a reasonably pure water.

For many rural areas, however, all that is necessary is to provide reserved tanks free from human pollution. The water of such tanks would generally be found to be pure, and especially if it could be drawn by a pipe from the centre of the tank, would always be quite safe for use. The actual provision of pure water, therefore, is not in itself a very difficult question. The real problem is how to provide administrative machinery that would enable Union Boards and other local authorities both to obtain supplies of water and preserve their purity.

3. **Conservancy.**—This is most difficult to carry out successfully. Here one has to consider removal and disposal of human excreta, house and other refuse, slop water, etc. In non-municipal areas there are practically

no arrangements for privies or latrines, people generally go to some open land, or banks of tanks or rivers for purposes of nature. These are fruitful sources of disseminating different forms of infection. Intestinal

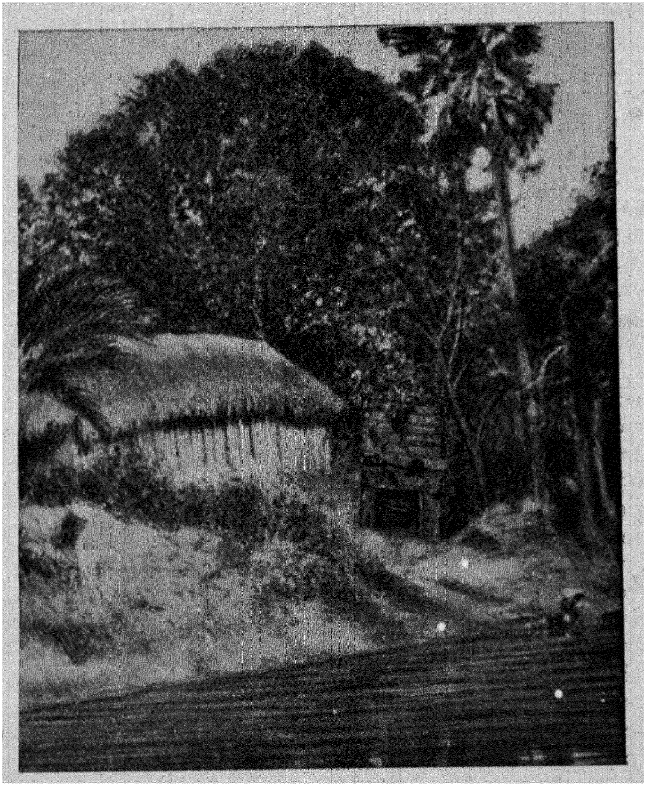

Fig. 96.—Showing Pollution of tanks in villages. Note an insanitary privy close to it.

parasites, notably ankylostomum duodenale, diseases like cholera, typhoid fever, etc., are all carried about through contaminated water. It is almost impossible

to stop this habit, inasmuch as people of means and education have recourse to this sort of open air privies. Children ease themselves anywhere and everywhere—such as the courtyard, or in or about the houses. Arrangements must be made for privies in every house, if this is not possible, public latrines should be constructed in suitable places and people are induced to use them. Where privies exist they are often situated close to tanks or wells, the water of which they pollute, not only by soakage, but by the washings which are carried directly into the water. The construction of these privies is imperfect and insanitary (*See* Fig. 96). For attending to the cleanliness of such latrines the villagers would do well to subscribe amongst themselves for engaging a *methar* (sweeper). Fouling of the seats is quite common, and if once they are fouled people will not use them, but will pollute the place all round it, not excepting the passage, and so create a terrible nuisance. There should be separate latrines for men and women—well protected and screened. If these latrines are not possible trench latrines are to be preferred. A simple method of combined latrine and trenching ground suitable for small communities is to have a plot of land properly fenced and divided into two portions. Each evening a trench is dug in the one division, the earth being piled on the side. The excreta are deposited in this trench and each person is instructed to cover the deposit with enough earth. A sweeper goes round in the evening and covers the dejecta more completely and digs a second trench to be used in the same way the following day. This way when the whole half portion of the plot is used up the other half is then used. People should be instructed not to use the tank for ablution purposes—a most common and pernicious habit. Where *methars* are engaged arrangements for proper disposal of night soil should be made.

Disposal of dry refuse is equally important. This consists of food waste, dust, refuse from stables, workshops and shops, dry leaves and flowers. All these undergo rapid putrefaction and give off offensive smell. They should be frequently removed and not

scattered about the house or thrown about the road. It is not uncommon to throw all refuse in the back yard where they collect in heaps. This is a very insanitary practice, the refuse undergoes decomposition and gives off offensive gases, breeds flies, and during the rains the polluting materials are washed away and contaminate tanks, etc. The flies are the greatest carriers of diseases like cholera, typhoid fever, diarrhœa, etc., and their breeding should be firmly checked. The refuse therefore should be properly disposed of. There are two practical ways of disposal of garbage. To bury it, or to burn it. In small places, burial is a very good method. The pits should be just big enough to hold a pail of refuse which is then covered over with three or four inches of earth on the top, and a new site selected for each successsive pail. It may also be utilized in reclaiming low lands, hollows (*Dobas*), etc. But they create a serious nuisance if not properly carried out and if located near to road side or dwellings. They must be covered with earth or rubbish from dismantled houses.

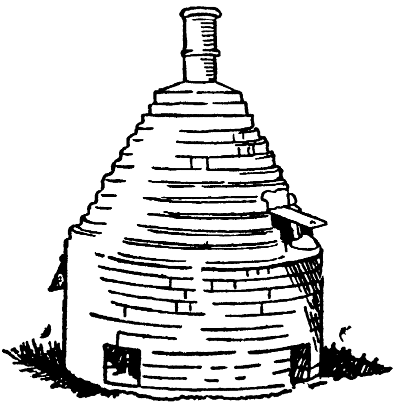

FIG. 97.—BEEHIVE INCINERATOR.
(From the Offical History of the War).

The night-soil and refuse may be disposed of together in a more sanitary way by incineration. This is possible where there is organised labour under proper control and sufficient fuel from refuse. Where the refuse consists of dry leaves, wood, etc., it may be utilised to supply the necessary inflammable material. A small incinerator as shown in the figure will be found quite efficient for the purpose. This type was extensively used with success

during the war under the name of "Beehive Incinerator." It is easy to construct, easy to manage, and would burn quite an enormous quantity of refuse.

It is built with a subterranean air space for draught, a central air cone, and at the level of the top of the air cone, and close to it, a perforated tray for burning fæces. The walls are made of brick, stone or similar material cemented together with a mixture of clay and cow-dung.

The subterranean air space gives just as good a draught as any other, and with an open air cone above its centre produces a draught when inflammable material such as, wood, paper, etc., are being burnt. A zone of intense heat is produced immediately around the air cone on which the perforated tray for fæces rests. The night-soil is rapidly dehydrated and charred and ultimately catch fire. The openings allow the liquid excreta, etc., to percolate through on to the bed of the fuel and refuse beneath which absorbs them. In the zone above the air cone, gases and smoke arising from its burning and destructive distillation of the contents are burnt, and what escapes from the funnel is practically only steam which is soon dissipated into the surrounding atmosphere.

If funds permit the night-soil may be disposed of by constructing what is known as "Dumping Septic Tank." By suitable arrangements, provided there is sufficient supply of water, the night-soil may be carried and allowed to pass into a septic tank.

The removal of slop water, rain water and other liquid filth is generally effected by surface drains in villages, both municipal and non-municipal areas. Ordinarily these are inefficient, ill-kept and are no better than dirty offensive puddles. They have no gradient, and during rains they become full of foul liquid which undergoes decomposition and putrefaction giving off offensive smell. These drains are no better than elongated cesspools, and not being made of any impervious material they act as sources of pollution of neighbouring tanks and wells through percolation. In most instances weeds and other plants grow on their sides and beds, and materially impede

the free passage of water. A proper system would be to have

1. Drains constructed with proper gradient, and made impervious with cement, or glazed half-channelled pipes.

2. They should be cleaned periodically and all weeds and plants removed.

3. They should not lead or open into any tanks or any other sources of water-supply.

4. They should be disposed of by irrigation over agricultural lands and outside any human habitation.

Disposal of the Dead.—Both man and animal when dead require to be disposed of properly. In villages dead animals are simply thrown away on the road or on the open land near about the house, where they undergo putrefaction and give off most offensive smell, while dogs and jackals carry them about creating great nuisance. Dead bodies are burnt anywhere and everywhere, or thrown into the river, and sometimes buried in the house. These are all most insanitary practices and prejudice the health of the people. It is therefore necessary that some rules should be observed with regard to all these dead bodies. Burning of the dead should be done only in some fixed place allotted for the purpose. It should be well protected from outside and no one should be allowed to throw dead bodies or half-burnt bodies into the water. Where there is a river burning should be done on the river-side and only burnt ashes should be allowed to be thrown into the water. Clothes, bedding, etc., should not be scattered about, but burnt down with the dead. If cremation is done near a tank, the tank must be kept separate, and the water should not be used for drinking purposes (*See* Disposal of the Dead page 287).

Protection against Malaria.—The reduction or suppression of malaria in villages is of vital importance inasmuch as four-fifths of Indian malaria occurs in villages. Although the broad principles for preventing the disease are the same whether one has to deal with cities, towns, cantonments and villages, yet the details by which these are carried out are not identical. The mass of people living in the villages are not only poor but ignorant

of the very rudiments of sanitation. Measures, therefore, to prevent mosquitoes from biting by the use of mosquito-proof houses, fans or punkhas, or culicides cannot be so freely and universally used. Reduction can only be effected by case-reduction in villages and by measures which will reduce the number of anophelines in and around them. It is therefore necessary that the *rationale* of our present-day prophylactic measures of malaria should be widely circulated and made known. In every village, persons capable of understanding the primary principles of prevention should be held responsible for the carrying out of preventive measures, and villagers should be impressed with their importance through them. *Travelling dispensaries* in charge of medical officers will serve a very useful purpose in distributing quinine and giving relief to villagers, especially during the malarial season. The people must be taught to help themselves and once they can be made to realise what "water-tidiness" consists in, elimination of the offending larvæ will be a comparatively easy task. The public should realise the true significance of watertidiness, and water should not be allowed to be collected in rejected vessels, broken tin boxes, etc., and shallow pools should be filled up. Instructions regarding the main facts connected with malaria should be given by popular lectures, and illustrated leaflets, in the vernacular of the place, circulated. The value of quinine as a prophylactic and the use of mosquito nets should be forcibly impressed on the public, and the prejudice against quinine, which so widely prevails, even amongst men of education, should be removed by all reasonable means. Where quinine is distributed amongst the masses, it must be done through some responsible person, who should see that it is actually taken and not thrown away, as is often done, by the ignorant villagers. The elementary principles of sanitation may be incorporated in text-books for children. Besides the above, the following special measures recommended by Hehir are of great value :—

1. The treatment of all cases of malarial fever and malarial enlargement of the spleen with quinine issued gratis.

2. The making of surface drains (even *katcha* drains) properly graded for removing rain water and refuse water generally.

3. Covering of all sources of water-supply with some mosquito-proof material.

4. The filling up of all burrow pits and excavations in and around villages for a distance of at least 100 yards.

5. The prevention of all cultivation within this 100-yard limit and of wet cultivation within 200 yards.

6. The keeping of this 100-yard area and the interior of the village free from mosquito larvæ.

General principles of prophylaxis against water-borne diseases :

(*a*) All discharges, fæces and urine, in which the organisms of disease are found are to be destroyed or disinfected as rapidly as possible.

(*b*) Flies are the principle carriers of these germs and therefore the food, milk, and water should be properly protected against flies. Kitchen should be made fly-proof. Flies breed in refuse and these should be properly disposed of.

(*c*) Since it is possible that apparently healthy persons may also harbour disease germs it is important that all excreta should be satisfactorily dealt with.

(*d*) Water-supplies, milk and other food should be protected from possibility of contamination by the so-called carriers.

(*e*) Boiling of water and milk, and thoroughly cooking other articles of food liable to be contaminated.

(*f*) Preventing washing of clothes and other utensils in or near a tank or well.

(*g*) Setting apart a tank for drinking purposes only, and not allowing washermen (*Dhobies*) to wash dirty and infected clothes.

(*h*) Preventing milkmen to use dirty water for cleaning pails and other utensils, or mixing suspicious water with milk.

(*i*) Using *bleaching powder* or *chlorinated lime* to sterilise all suspicious waters of tanks or wells.

CHAPTER XXV

SANITATION OF FAIRS AND RELIGIOUS FESTIVALS

THE sanitation of fairs and religious festivals in India is a very important and complicated task. Every time that a fair or a mela is held, or there is a religious pilgrimage, it is followed by epidemic of water-borne diseases, chiefly cholera. Places for pilgrimage in India are many, some are of permanent nature, while others are temporary. Permanent centres are places possessing special religious sanctity and which attract quite a large number of pilgrims all the year round. These are, Hardwar, Benares, Muttra, Brindaban, Puri, Kalighat in Calcutta and Tarkeswar in Bengal. In temporary centres pilgrims congregate in large numbers at certain time of the year only. Thus during a bathing festival people congregate by thousands along the banks of the sacred rivers which afford sufficient opportunities for pollution of water and spread of disease. The figure 98 shows how the river Ganges is being used for bathing purposes during such a festival.

Abundant evidence is now available that these congregations of people, either in the different pilgrim centres or in the different melas and fairs are frequently responsible for the outbreak and spread of diseases disseminated by close personal contact, by contamination of food and water, and by the agency of flies.

The organisation of sanitary control sufficient for the wants of ordinary pilgrim traffic in the many permanent centres is not so difficult. But efficient sanitary oversight during special melas or festivals, which take place at recurring intervals is a very difficult problem and cannot be so easily managed. Since different fairs vary greatly in style and character it is not possible to formu-

late fixed rules that will apply to all such places under all conditions. Success depends upon everything being planned out and arranged previously. The entire area should be divided into isolated plots, and each such plot should be in charge of one or more sanitary officers, who should see that the latrines are kept clean, that the lodging houses are free from any sickness and kept in proper order, and that the rules laid down for the management of the lodging houses are obeyed. The number of carts, sweepers, scavengers and the inspectors necessary must

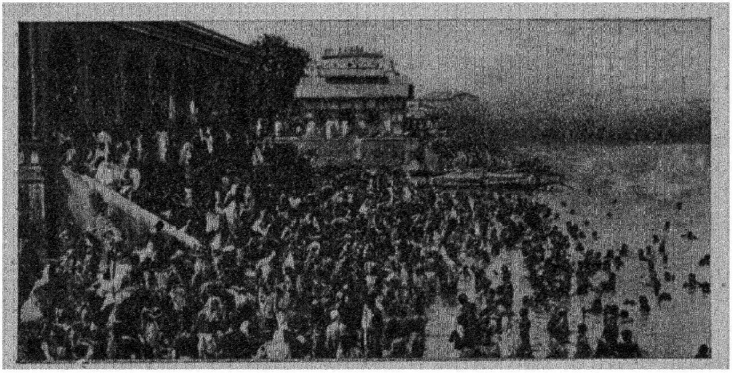

FIG. 98.—AN INDIAN RIVER DURING A BATHING FESTIVAL.

be calculated beforehand on the basis of the approximate number of people likely to be present. Lodging houses should be registered and the number of lodgers to be accommodated in each should be fixed. Ventilation, drainage, cleanliness, water supply and privy accommodation must be spervised before each such house is licensed. For the efficient control during these fairs and melas the following require careful attention, viz. :—

1. Accommodation.
2. Medical and sanitary arrangements.
3. Water supply.
4. Efficient conservancy.
5. Pure and wholesome food.

1. **Accommodation.**—The management of the lodging houses for the accommodation of the pilgrims has been detailed above. But the site where the fairs should be held requires some consideration. Wherever possible the land selected should have natural drainage, well shaded and watered. It should be laid out previously and kept ready before the arrival of the first batch of pilgrims.

The site shall be cleared of jungle and dense vegetation and the approach road shall be metalled or otherwise made firm. In cases of large fairs a second broad road shall be provided for the returning pilgrims. The place should be carefully marked out and provision made for the accommodation of officers-in-charge, the police, the hospital, the booths, residential blocks and latrines.

2. **Medical and Sanitary Arrangements.**—Every fair shall be under the medical and sanitary charge of the medical officer of health in whose jurisdiction it is held. The sanitary officer shall be always on the watch to detect any case of infectious disease occurring in or near the fair. The whole area shall be divided into blocks and each block shall be under the charge of a sanitary inspector who shall daily inspect the area under him and report occurrence of any suspicious case of illness. Arrangement shall be made to receive daily report from the sweepers in charge of each latrine of any case of unusual diarrhœa or any similar disease.

For the removal of the sick stretchers or *doolies* shall be provided at the fair hospital and also at the police outposts. Gangs of bearers shall be kept in readiness to carry patients. Unless there is a permanent hospital or dispensary, every fair shall be provided with a temporary general hospital and an isolation hospital. They may be conveniently placed in one of the side roads away from the main road and preferably on the open land.

For the accommodation of the infectious cases temporary huts may be erected, on for the male patients, and one for the female patients, with quarters for the medical officers, servants, etc. Latrines with wooden seats and

iron pans or earthen receptacles shall be placed close to the wards. All the dispensaries should be equipped with prescribed standard drugs and stores, stretchers, doolies, disinfectants—such as hycol, cyllin, and vessels for boiling water, etc.

3. **Water Supply.**—This is of utmost importance and since most of the pilgrims are affected with water-borne diseases every source of supply shall be under proper supervision to prevent improper use and contamination. Where filtered water-supply is not available deep tube-well should be provided for. In the absence of these a sufficient number of masonry wells or reserved tanks shall be constructed. All temporary or *kutcha* wells shall either be closed or treated with bleaching powder. It wells are used satisfactory mechanical arrangement shall be made for drawing water, and indiscriminate use of other vessels shall be strictly forbidden. Where there are sufficient number of existing tanks a few shall be selected and reserved for drinking purposes, and no one shall be allowed to wash on the banks or bathe. The above precautions should also be observed in case of rivers, where such exist, to protect the water from pollution. Sweepers shall patrol the banks of rivers and tanks in the morning and evening to remove all filth found there.

Burning ghats should be located well down the stream beyond the fair limits.

4. **Efficient Conservancy.**—For this an adequate staff of properly paid sweepers must be employed. The whole gang should be divided into groups in charge of a mate and every sweeper must bear a numbered badge.

Female sweepers should be employed for latrines meant for women.

The sites for latrines must be previously located and their construction supervised by the sanitary inspector. In the construction of the latrines the following points should be attended to :—

(*a*) They should not be too far away, or else the people will not use them.

(*b*) No latrine should be more than hundred yards away from the fair limit.

(*c*) The inhabited site of most fairs should be laid out in rectangular blocks and behind each one or two blocks the latrines should be situated.

(*d*) In the fairs where the people visit daily and do not live there, two seats for every 1000 people may be taken as the average.

(*e*) For pilgrims living within the area of the fair, one seat for every 100 person may be taken as a fair average.

The type of latrine best adapted is a trench latrine. A trench of a forty feet long, ten to twelve inch wide and eighteen to thirtysix inches deep is quite convenient. The earth is pulversied and kept behind the trench

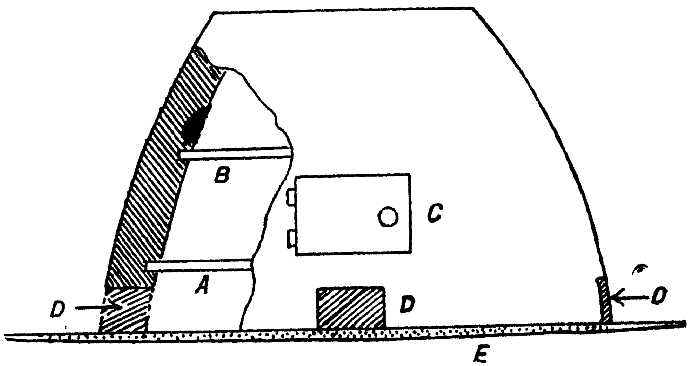

Fig. 99.—Double-grid Beehive Open Incinerator.

A-lower grid for incineration ; B-Upper grid for drying ; C-Stoking door ; D-draught holes ; E-Cement base.

(From The Official History of the War).

leaving a space about six inches along the border of the trench for the foot rest. Movable screens are placed both in front and back of the trench behind the accumulated earth. By placing screens three feet wide across the trench separate compartments are easily made, each screen being three feet away from the other one. By a partition placed in the middle, each forty feet trench is divided into two sections and each section shall accommodate seven seats.

When the first trench is filled the screen in front of it is removed and placed behind the second one and in this way as many trenches as are required may be utilised.

Every latrine must be constantly kept in a state of cleanliness and shall be properly lighted at night. To prevent people from using places other than the latrines the approaches should be kept scrupulously clean, all vegetations and high crops near or about the fair previously cutdown and removed. All shallow depressions, pools and back-water should be filled up.

Public urinals shall be placed at the corner of every block of the inhabited side of a fair. In ordinary soil a pit four feet square and five feet deep fitted with broken *jhama* four feet deep should be made and at each corner a kerosine tin full of sawdust with a perforated bottom is placed soaked in $HgCl_2$.

Satisfactory arrangements for the disposal of refuse and baskets for carrying the same must be made. The refuse may either be dumped in a place previously prepared for the purpose or best incinerated. Temporary incinerators of the "Beehive" pattern or open incinerators will serve the purpose quite satisfactorily. A description of the closed Beehive incinerator will be found on page 559. Although the burning of solid excreta in an open incinerator is not theoretically satisfactory, it was carried out quite satisfactorily in all the theatres of war, during the last war and may with advantage be utilised in cases of fairs and melas as a temporary measure.

5. **Food Supply.**—Arrangements shall be made for the supply of pure and wholesome food at reasonable cost. The sanitary inspector should examine the milk, fish and other foods and should see that these are kept in cleanly conditions. Unwholesome food, over-ripe fruit and decaying vegetables shall be strictly forbidden within the fair area. If these are discovered they should be seized and destroyed as a preventive measure.

APPENDIX I

The Duties, &c., of District Health Officers in Bengal

In addition to the duties imposed upon him by any law, for the time being in force, regarding public health, every District Health Officer shall perform the following duties :—

(1) He shall perform all the duties imposed upon him by properly constituted by-laws and regulations of the District Board in respect of any matter affecting public health.

(2) He shall attend the meetings of the Sanitation Committee of the District Board.

(3) He shall execute and enforce the regulations, rules and orders, relating to public health, which may be enacted, made or issued by competent authority.

(4) He shall keep himself informed, as far as practicable, respecting all influences affecting or threatening to affect injuriously the public health in the district. For this purpose, he shall visit the several areas or localities under his jurisdiction, as occasion may require.

(5) He shall inquire into and ascertain the causes, origin, and distribution of diseases within the district; and ascertain to what extent the same depend on conditions capable of removal or mitigation.

(6) He shall consult with the Health Officers of municipalities within his district whenever the circumstances may render this desirable.

(7) He shall advise the District Board on all matters affecting the health of the district and on all sanitary points involved in the action of the Board ; and, in cases requiring it, he shall certify, for the guidance of the District Board, as to any matter in respect of which the certificate of a medical officer of health is required as the basis or in aid of sanitary action.

(8) He shall, from time to time, inquire into and report upon the accommodation available in hospitals or dispensaries either maintained or aided by the District Board for the isolation of cases occurring in the district of (*a*) cholera, (*b*) small-pox, (*c*) plague, and (*d*) other infectious diseases, and upon any need for the provision of further accommodation.

(9) On receiving information of the outbreak of any infectious or epidemic disease of a dangerous character within

the district, he shall visit without delay the locality where the outbreak has occurred, and inquire into the causes and circumstances of such outbreak ; and in case he is not satisfied that all due precautions are being taken, he shall advise the persons competent to act as to the measures which appear to him to be required to prevent the extension of the disease, and shall take such measures for the prevention of disease as he is legally authorized to take under any law in force in the district or by any resolution of the District Board.

(10) Subject to the instructions of the District Board, he shall direct or superintend the work of the subordinate public health staff of the district, and on receiving information that his intervention is required in consequence of the existence of any nuisance injurious to public health, he shall, as early as practicable, take such steps as he is legally authorized to take.

(11) He shall pay particular attention to the water-supply of the district, especially if it is derived from public wells or reserved tanks. He shall report to the Chairman if the public wells are not kept in good repair and if the reserved tanks are not properly fenced and kept free from contamination, and he shall render every assistance to ensure the purity of the water-supply.

(12) In order to facilitate the adoption of measures for reducing the prevalence of malarial fever, he shall have a careful survey made of the distribution of malaria in the district. When, as a result, of this survey, he has obtained an accurate knowledge of the distribution and relative intensity of the malaria existing in different parts of the district, he shall prepare a detailed scheme of antimalarial sanitation designed to meet the existing conditions, and shall submit it to the Chairman of the District Board for the approval and sanction of the Board.

(13) He shall see that vaccination is carried out thoroughly and efficiently by the subordinate public health staff of the District Board. In the course of his tours of inspection, he shall carefully ascertain, in the case of every village inspected, the proportion of children protected and those not protected by vaccination, and shall report the same to the Chairman.

(14) He shall arrange for the attendance, either of himself or of members of the subordinate public health staff, at important *melas*, fairs, religious festivals and agricultural exhibitions in the District Board area, and for the erection of temporary latrine accommodation and the protection of the water-supply, in order to guard against the occurrence of water-borne disease.

(15) If he is of opinion that any trade or occupation or the keeping of any goods or merchandise, by reason of its being injurious to the public health, should be suppressed or removed or prohibited or that action should be taken regarding

any public nuisance, he shall report the matter to the Chairman, so that action may be taken under section 133 of the Code of Criminal Procedure, 1898, or any other provision of law.

(16) He shall, from time to time, but not less than once every month, report in writing to the District Board his proceedings and the measures which may require to be adopted for the improvement or protection of the public health in the district. He shall in like manner report with respect to the sickness and mortality within the district, so far as he has been able to ascertain the same.

(17) He shall forthwith report to the Sanitary Commissioner any case of plague, cholera, or small-pox, or any serious outbreak of epidemic disease in the district which may be notified to him, or which may otherwise come or be brought to his knowledge.

(18) He shall, as soon as practicable, after the 31st day of December in each year make, in a form prescribed by competent authority, an annual report to the District Board up to the end of December, on the sanitary circumstances and the sanitary administration of the district.

(19) At least a month before the date for the preparation and consideration of the annual budget of the District Board, he shall submit a programme of the sanitary works and improvements which he proposes for execution during the following year.

2. Every District Health Officer is entitled to draw travelling allowance in accordance with the rules for the purpose in the Civil Service Regulations for journeys performed on duty.

3. Every District Health Officer is entitled to the benefit of the leave rules under the Civil Service Regulations, should there be no separate approved set of leave rules prescribed by the District Board under which he is employed.

4. The appointment, removal and dismissal of every District Health Officer is subject to the approval of the Commissioner of the Division in which the district is included.

5. Every District Health Officer shall be directly under the orders and control of the Chairman of the District Board.

6. The subordinate public health staff of a District Board will be under the immediate orders and control of the District Health Officer.

(*Bengal Government, Municipal Department Circular No.* 25-29*T.—San., dated the 9th June* 1920.)

Instructions for District Health Officers in Bengal

1. The District Health Officer shall communicate to the Health Officer of a municipality situated within the district any information which he may possess as to any danger to health threatening that municipality.

2. He shall see that the subordinate public health staff are diligent in searching for omissions in the register of births, and as far as possible that careful watch is kept at burial-grounds and burning ghats to ensure that bodies are properly disposed of and that every death is duly recorded.

3. In consultation with the Chairman he shall arrange for the delivery at important *melas*, fairs, religious festivals and agricultural exhibitions of simple lectures on sanitation and the prevention of disease, illustrated, if possible, by magic lantern slides. With the permission of the Chairman and of the local educational authorities, he may also deliver, lantern lectures on sanitation and the prevention of disease in such schools as he may from time to time visit.

4. Whenever necessary or advisable, or whenever directed to do so by competent authority, he shall inspect the sanitary condition of railway stations and steamer ghats in his district, reporting the result of his inspection to the District Board, the District Magistrate and the Sanitary Commissioner simultaneously.

5. Every Monday he shall forward to the Sanitary Commissioner by post, at such an hour as in the ordinary course of post will ensure its delivery to the Sanitary Commissioner on the following Tuesday morning, a return in such form as the Government or the Sanitary Commissioner may from time to time require, showing the number of cases of infectious disease notified to him during the week ending on the preceding Saturday night. He shall also forward at the same time duplicate copies of the return to the District Magistrate and to the Health Officer or Officers of any municipality or municipalities in his district.

6. He shall transmit to the Sanitary Commissioner, the District Magistrate and the municipality or municipalities in his district copies of his annual report and of any special report.

(*Bengal Government, Municipal Department Circular No.* 367—71 *San., dated the* 2nd *July* 1920.)

APPENDIX II

The Duties of Sanitary Inspectors

1. (1) *Control of Conservancy Department.*—The principal duty of Sanitary Inspectors is to see that the Conservancy Department does its work properly. They must therefore divide their time between the various branches of that department.

(2) Sanitary Inspectors must particularly bear in mind that it is their business not merely to order work to be done but to see that it is actually carried out.

2. (1) *Inspection.*—The Sanitary Inspector must commence his inspection at an early hour in the morning when the actual cleaning operations are in progress. When passing round his ward or town, he must see that the scavengers are at work, and that the rubbish is being properly removed and that the road drains are cleaned.

(2) He must visit all public latrines and urinals and a large number of private privies and cess-pools. In this connection, he must arrange to meet the *jamadar* of the private latrines, Conservancy Department, daily and receive his report as to whether any complaints have been made and whether the department is working satisfactorily.

(3) He must not consider that his duties indicated in sub-rules (1) and (2) are complete until he has seen the street rubbish properly removed and the night-soil from the public latrines carried away to the trenching-ground.

(4) He must keep a note-book in such form as the Chairman of the Municipality may prescribe, in which he shall record the particulars of such defects in private privies or latrines as require action by the owners and of the action taken to remove them.

(5) In the course of his round, he must—

(*a*) take note of any useless undergrowth and tanks that require clearance, and report the same to the Medical Officer of Health [*Chairman of the Municipality*],* and

(*b*) check the muster-rolls of the *methars* and menials.

3. (1) *Conservancy animals and property.*—He must pay particular attention to the condition of the conservancy animals, seeing that the *gowkhana* is kept clean, that the bullocks are properly fed, and that all their minor ailments are treated at once.

(2) If serious diseases, such as rinderpest and anthrax, appear in the *gowkhana*, he must take every possible precaution and must, without delay, obtain the help of the veterinary assistant, if one is available.

(3) He must also see that the conservancy carts, night-soil buckets and other tools and plant of the Conservancy Department are kept clean and in proper order.

4. (1) *Markets.*—In the course of his round, the Sanitary Inspector must inspect all markets, buildings, ships, stalls or places used for the sale or storage of articles intended for food.

(2) If he finds in any market, building, shop, stall or place used for the sale or storage of articles intended for food, or as a slaughter-house, any articles which appear to be unfit for food, he must seize them and report the matter at once to the Medical Officer of Health [*Chairman of the Municipality*],* who will thereupon take suitable action under the Bengal Municipal Act, 1884.

4A. (1) He shall make regular inspections of cowsheds and dairies and report whether they are in a sanitary condition. He shall also see that the milk-vessels kept for such cowsheds or dairies are properly cleansed and sterilised.

(2) If when making any such inspection or at any other time he detects any contagious or infectious disease amongst milch-cattle, especially tubercular diseases of the udder, he shall report the fact to the Health Officer [*Chairman of the Municipality*] * and shall take such precautions as may be necessary.

5. *Trenching-grounds.*—He must visit each trenching-ground at least three times a week, and must see that all sewage is properly buried there :

Provided that this rule shall not apply in towns where there is a special Sanitary Inspector deputed to be in sole charge of this part of the conservancy work.

6. (1) *Births and deaths.*—In the course of his inspection, the Sanitary Inspector must take note of all births and deaths that he may hear of, and must report them to the Municipal Registrar.

(2) He must also visit burning-ghats and burial-grounds once a week, if any exist within his ward or town, and enquire into the number of bodies disposed of there since his last visit.

7. *Epidemic diseases.*—He must at once report to the Medical Officer of Health [*the Civil Surgeon or the Chairman of the Municipality*] * the outbreak of epidemic diseases, such as cholera, small-pox and plague, or any suspicious increase in the mortality or sickness of his ward or town.

8. (1) *Prevention of encroachments on road or drains, and pollution of water-supply.*—He must bring to the notice of the Medical Officer of Health [*the Chairman of the Municipality*] *

any encroachment on to any road any illegal covering up of the municipal drains.

(2) He must also report to the same officer the insanitary condition of any well or tank, any defects in the water-hydrants and the name of any person who wastes the public water-supply.

(3) He must inspect all sources of public water-supply and take steps to prevent pollution of the water and the spread of water-borne disease by calling the attention of the Medical Officer of Health [*the Chairman*] * to any case in which it appears necessary to take action under sections 198 to 200 of the Bengal Municipal Act, 1884.

9. *Slaughter-houses.*—He must inspect all slaughter-houses from time to time, and must see that they are kept in a clean and sanitary condition, and that all refuse is removed therefrom to the trenching-ground.

10. *Daily report.*—In the afternoon of each working day, he must go to the office of the Medical Officer of Health [*the Chairman*] * to make his report and to receive any orders that may be given to him.

He must also report any instance of a public nuisance within the municipality which requires immediate removal for the sake of public health and safety.

11. *Hostels and sarais.*—He must, from time to time, inspect all hostels and *sarais* within the municipal area.

12. *Knowledge of certain provisions relating to the public health.*—He must be thoroughly conversant with all sections of the Bengal Municipal Act, 1884, which relate to the public health.

* The words in italics within square brackets should be substituted for "the Medical Officer of Health" in municipalities in which there is no such officer.

(Circulars Nos. 2072-76M., dated the 29th October 1915, and No. 8 San., dated the 28th February 1917, by the Government of Bengal, Municipal Department).

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